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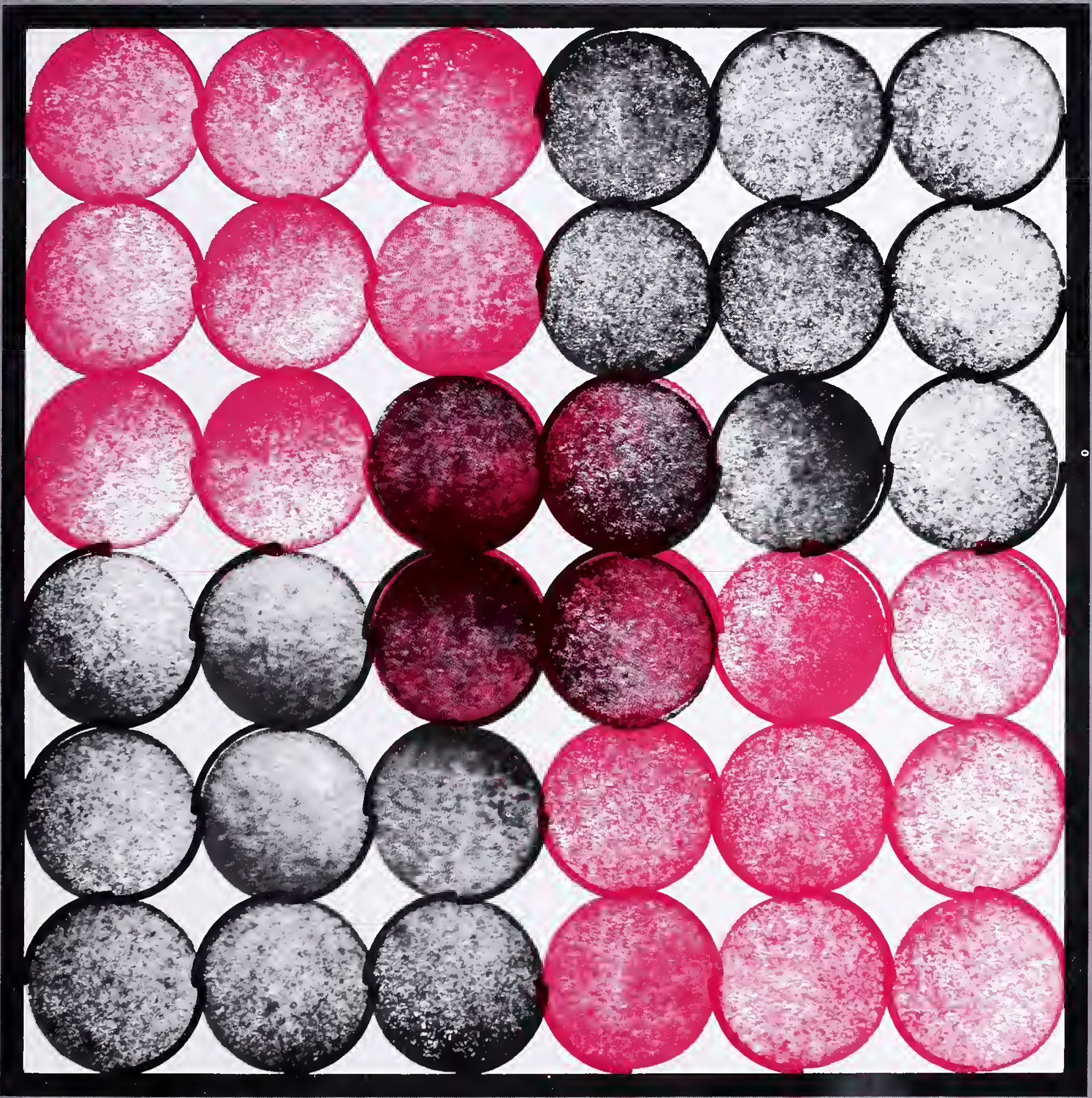
RD&A MAGAZINE

March - April 1986

RDE CENTERS

PM MATERIEL SYSTEMS ASSESSMENT



ENGINEERING FOR TRANSPORTABILITY

AAWS-M ACQUISITION STRATEGY

ARMY Research Development Acquisition RD&A

Vol. 27 No. 2 MARCH-APRIL 1986

OFFICIAL MAGAZINE OF THE RDA COMMUNITY, established 1959

Assistant Secretary of the Army (Research, Development and Acquisition)
Dr. Jay R. Sculley

Department of the Army Deputy Chief of Staff for Research, Development and Acquisition
LTG Louis C. Wagner, Jr.

Commanding General U.S. Army Materiel Command
GEN Richard H. Thompson

Editor **LTC David G. Kirkpatrick**
Associate Editor **Harvey L. Bleicher**
Assistant Editor **Deborah D. Magga**

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ABOUT THE COVER:

The front cover highlights some of the key articles in this issue: the acquisition strategy for the Advanced Antitank Weapon System—Medium, the PMSA Program for all PM-managed systems, the role of the new RDE centers, and the importance of designing new systems for easy transportability. The back cover shows an experimental apparatus related to a feature article on squeeze film damper bearings. Cover designed by Daniel Jeffrey Marks.

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Interview With

MG Garrison Rapmund

CG, Army Medical R&D Command and Assistant Surgeon General for R&D

Q. ***What is the primary mission of the assistant surgeon general for research and development?***

A. I have a staff function and an operational function. My staff function as the assistant surgeon general for research and development is to advise the surgeon general and the Army staff on the health and medical aspects of all Army research, development, test and evaluation programs, including personnel, resources and facilities required to conduct these programs. I have staff responsibility for Department of Defense medical R&D programs for which the Army is lead agency. This includes infectious disease and combat dentistry research and development, and executive agency responsibility in medical chemical warfare defense, medical biological warfare defense, and nutrition research and development. Another staff function is to coordinate Army medical R&D activities with other federal agencies, with similar activities in foreign countries, and with civilian commercial and academic research organizations.

My operational function is to command the U.S. Army Medical Research and Development Command, and to serve as the medical materiel developer.

The command has five research programs and 11 units focused on the occupational health and safety of soldiers. Our mission is to protect soldiers from infectious diseases they might encounter through deployment to endemic areas or exposure to biological weapons; to improve medical care on the battlefield by placing the best tools and techniques in the hands of the combat medic; to protect our soldiers from environmental health hazards and from the health hazards posed by their own weapons, equipment and vehicles; to improve military dental care, maxillofacial surgery and wound infection control; and to medically protect soldiers from chemical weapons, and improve medical management of chemical casualties.

Q. ***The Medical R&D Command is responsible for a multi-faceted R&D effort. What are some of the current high priority programs which offer the greatest potential payoffs?***

A. Some of our high priority infectious disease and biological defense projects have potential for big payoffs.

Our malaria program includes vaccine development, field testing of new anti-malarial drugs, and evaluation of artemisinin, the active principle isolated by the Chinese in one of their traditional herbal remedies for malarial treatment. Every step we take toward increased protection against malaria is a payoff, because malaria is still a major public health threat in much of the world; it was an important casualty producer in every war the United States has fought and still remains a serious threat to soldiers deploying in the tropics.

In our biological defense program we are exploring novel approaches to vaccine development, including genetic engineering and other advanced technologies. We are developing recombinant multivalent vaccines that will combine immunity to several diseases within a single preparation, and immunomodulatory drugs that will be used to stimulate immunity against whole classes of infectious agents. Much of this research is conducted through contracts with many leading universities and research institutes, and through these contracts we are supporting very advanced medical research. Experience has shown that there is a substantial return for investing in new knowledge which has paid off in improved protection from infectious disease, benefiting both military and civilian medicine.

Medical chemical defense was until recently our highest priority in the sense that it had the largest share of our budget. Chemical weapons have been used in the Iran-Iraq War, and they are a significant element in the strategic balance and arms reduction talks. Success in protecting our personnel against the threat of chemical weapons might further deter their use in the future. Such deterrence would be a significant additional payoff in R&D dollars.

Q. ***Please expand on specific developments in surgical restoration during the last decade which will lead to more lives saved on the battlefield.***

A. Several products are currently being developed that will aid the surgical management of the soldier on the battlefield. We are working on a skin replacement that includes both epidermis and dermis layers, and will adhere to body tissues when applied to a wound and eventually be replaced by new skin. Medics would carry it in packaged, freeze-dried form.

We are also developing a resuscitation fluid production system which will generate medical grade water for injection on the battlefield. These two systems will be important improvements in the initial care provided by the medic on the battlefield. Care at this early stage is very critical to saving lives.

Wound dressings and microencapsulated antibiotic preparations are being formulated that will be capable of sustained release of broad-spectrum antibiotics into wounds. These systems will prevent and/or eliminate infection in wounds and will reduce morbidity and mortality from wounds incurred on the battlefield.

> **"Experience has shown that there is a substantial return for investing in new knowledge which has paid off in improved protection from infectious disease, benefiting both military and civilian medicine."**

We are also developing a biodegradable polymeric bone implant material that will be used to replace missing bone segments. After implantation, the biodegradable repair material will stimulate new bone formation which will slowly replace the repair material.

A biodegradable fracture fixation system for setting broken bones is also being developed. This system will rigidly hold the fractured bone in place while healing occurs. After healing is complete, the fracture fixation system will biodegrade and be absorbed by the body. Some non-biodegradable metal fracture fixation systems must be surgically removed after the bone has healed. The new system will not require this second surgical procedure.

Q. ***What were some of the "lessons learned" by the Army's medical R&D community as a result of the Vietnam experience and more recently, the Grenada operation?***

A. U.S. Army surgeon MAJ W.S. King commented after the first battle of Bull Run that, "Diseases destroy more soldiers than do gunpowder and the sword." The Vietnam conflict was no exception to this rule. Disease was listed as the cause of 56 to 74 percent of admissions to hospitals in Vietnam, from 1965 to 1970. The conflict in Grenada was marked by significant incidence of infectious disease. Up to 47 percent of the members of the initial assault battalions were infected by hookworm. The shortness of the operation precluded the disease from having an impact on the fighting strength available to the commander. The bottom line is that even in a brief, well supported operation, infectious diseases will still pose a serious threat to mission completion.

In two important areas we have had to be careful not to be deceived by our experience in Vietnam. With complete air superiority in that conflict, and because of the small geographic size of the country, we could fly any casualty directly to whatever type of definitive care was needed. In future conflicts, this will probably be impossible, and the importance of the echelon system of health care will be re-emphasized.

After Vietnam, statistics seemed to indicate far higher survival rates among casualties. An Army medical researcher took a closer look at these numbers, and saw that in Vietnam many uninjured people reporting to sick call were "carded for record only" and counted with the real casualties. This gave the appearance of a greater survival rate. He reached the conclusion that survival rates have not increased significantly over the World War II and Korea rates.

Q. ***How does medical R&D compare with weapons systems R&D in terms of program length, levels of risk, cost and other factors?***

A. Historically, program length for development of medical products has averaged three to eight years which includes basic research to production and fielding versus nine to 15 for weapons systems.

Levels of risk are significantly greater for medical products (e.g., drugs and vaccines) than for weapons. Not only do we follow the same regulations governing materiel acquisition that weapons systems do, in contrast we must also be in full compliance with the regulatory requirements of the Food and Drug Administration regarding products intended for human use. For example, if the pharmaceutical industry utilized the DOD materiel acquisition process, their data indicate that 90 percent of their products fail before a Milestone III In-Process Review. There is no assurance that a drug or biological (vaccine) will be safe or effective until it is employed in clinical trials.

A cost comparison is difficult, but in general, development of medical products is less expensive than weapons systems. For example, the cost of a single vaccine for administration to two million armed forces personnel could range from $5 to $35 million. Cost benefit must also be considered, e.g., in contrast to a weapons system, a vaccine (smallpox, yellow fever, tetanus, polio, etc.) prevents morbidity and does not require any cost to improve or expand its capability. Once the vaccine is developed, the threat posed by the particular disease is negated.

Q. ***The Department of Defense has initiated a major effort to streamline its materiel acquisition process. What is the Medical R&D Command doing to improve its acquisition process?***

A. A number of streamlining measures have been initiated. We are adapting the Life Cycle Management System to the process of fielding medical materiel. Three project managers have been designated so that all medical products are overseen by a project manager.

We have centralized all our contracting for research and development in an Acquisition Management Office, under the direction of the surgeon general's principal assistant responsible for contracting. A unified approach to contracting will help technical project officers within our laboratories and institutes, research area directors in the headquarters, and project managers. We have published a broad agency announcement describing our research programs. The announcement also describes procedures for proposal submission, which has helped potential contractors submit complete, easy-to-review proposals.

We are initiating a Dual Track Development Program. This will combine rapid acquisition of available medical materiel for contingency planning with a second development effort to adapt materiel to our needs. For example, a drug currently on the market that provides five or six hours of therapy would be purchased for possible use; at the same time, we would work to develop a longer acting form of the drug, one that would provide 12 to 24 hours of therapy, which would better meet operational requirements.

Finally, this command is vigorously pursuing those aspects of biotechnology that will shorten the classical methods of vaccine and drug development. An example of this is a malaria vaccine that will progress from Milestone I through Milestone III in less than four years.

Q. ***Can you cite some of the major "spin-off" products that have benefited the civilian community as a result of Army medical R&D efforts?***

A. Products developed to protect the armed forces from infectious disease are readily usable by the civilian community. Of interest to American physicians are vaccines against bacterial meningitis, upper respiratory infections from adenoviruses, and Rocky Mountain Spotted Fever, to name just a few. However, our infectious disease products probably have their greatest impact overseas. An Army-developed vaccine against Venezualan Equine Encephalitis was instrumental in stopping an epidemic of this disease in South and Central America in the early 1970s. The anti-malarial agent mefloquine is an essential ingredient in the combination drug Fansimef, the most recent product to be fielded for prophylaxis against drug-resistant falciparum malaria.

Products which are undergoing clinical trial in volunteers, or are about to do so, include vaccines against diarrheal diseases and malaria; these diseases are major killers of children in the underdeveloped nations. Vaccines against gonorrhea, infectious hepatitis and dengue fever are also slated for clinical testing, as well as a tropical anti-penetrant for protection against schistosomiasis.

> ***"Levels of risk are significantly greater for medical products (e.g., drugs and vaccines) than for weapons."***

Army medical researchers contributed to studies of the human immune system which led to development of immunomodulators such as interleukin. Current Army research with anti-viral drugs is expected to lead to improved protection from infectious diseases.

The U.S. Army Institute of Surgical Research, or the Army Burn Unit, pioneered treatment and medical management of burn victims during the 1960s. Knowledge, materials, and techniques developed by the Army have been transferred to civilian burn treatment centers.

In its application of lasers to military tasks, the Army developed safety standards for their use in the laboratory and in operational environments.

Q. ***To what extent does the Army depend on foreign medical technology?***

A. I would not say that we are dependent on foreign medical technology but I would say that we have an obligation to learn whatever we can from it. There is a great amount of technical expertise demonstrated in the medical materiel of our European and other allies. Two examples are the French Parachutist Surgical Unit and the German chemical decontamination unit. Both of these systems combine efficiency, mobility and high quality components.

CPT Lewis R. Boobar, research entomologist at USAMBRDL, adjusts electrical input to the Army Insecticide Measuring System Aspirator he designed.

New Instrument for Aerosol Characterization

The U.S. Army Medical Bioengineering R&D Laboratory (USAMBRDL), Fort Detrick, Frederick, MD, has announced development of an aspirator for use in characterization of droplet size and distribution down range of aerosol generation. It will serve as an accessory to the Army Insecticide Measuring System (AIMS).

The AIMS was developed as a contract effort of the USAMBRDL to measure, count, and sort one to 450 micron size aerosol droplets at the point of dispersal. Droplet characterization is necessary to calibrate pesticide sprayers used in controlling disease carrying insects. The insect measuring system determines droplet diameters by measuring resistance changes in a platinum hot-wire resulting from the cooling effect of evaporating droplets that strike the wire.

After entomologists obtained rapid, accurate aerosol characterization at the point of dispersal, they examined characterization of aerosol clouds down range, at the point of impact. However, because of diffusion, drifting, settling, and dispersion in the atmosphere, the measuring system was unable to obtain sufficient droplets for meaningful readings at down range locations.

This problem was addressed with development of an aspirator which generates air flow through a cylinder to concentrate the aerosol and increases the number of droplets passing over the probe. Tests have shown that it is now possible to immediately characterize the droplet size and distribution in a treatment area.

Because of its small size, the aspirator can be placed inside or adjacent to insect test cages to accurately characterize, calculate and standardize minimum lethal doses of pesticides. Final development tests on the AIMS and the aspirator are in progress.

Research, Development & Engineering Centers

By Dr. Timothy M. Small

Army Materiel Command (AMC) research and development organizations are being restructured to perform their functions more effectively in the management and program execution of systems acquisition. At the same time, the way AMC acquires equipment is undergoing significant change. An article in the January-February issue of Army RD&A Magazine *focused on the U.S. Army Laboratory Command (LABCOM) and its role in the acquisition process. The following article continues the review of AMC's organizational initiatives, addressing the Research, Development, and Engineering (RDE) centers; their relationship with LABCOM; and their intrinsic role in the streamlined acquisition process.*

Review

As a result of recent initiatives, AMC has two distinct types of research, development, and engineering organizations, which complement one another in their structures and efforts. These are the corporate laboratories, assigned to LABCOM, and the commodity aligned RDE centers, assigned to the commodity commands. Key responsibilities of LABCOM, as described in the last issue of this magazine, are shown in Figure 1.

The RDE centers are improved versions of what were called R&D centers. The addition of an "E," for engineering, to their titles reflects the breadth of their roles. They are the commodity oriented research, development, and engineering "centers of excellence" of the AMC commodity commands. For its assigned commodities, each RDE center is a "full service" developer/integrator of technology, launcher of system developments, and source of life cycle engineering support.

Acquisition Strategy Considerations

As noted in the previous article, many factors were considered in formulating the organizational effectiveness improvement initiatives and the subsequent conceptualization of an "RDE center." Most of these factors are directly linked to achieving AMC's central materiel acquisition objective—successfully getting quality, responsive systems (and system improvements) to the troops promptly and with minimal disruption and cost. This strategic goal forms the basis for initiatives to improve the materiel acquisition process and, in turn, drives AMC Headquarter's formulation of the R&D system structure; i.e., organizational configurations, interorganizational relationships, functional assignments, and policies.

For example, some required new or enhanced system capabilities are achievable by one or more of various shortcut acquisition strategies. The RDE centers must be fully capable of identifying such opportunities and playing their part in exploiting them. Examples of expedient strategies include:

- improve already fielded equipment (product improvements);
- procure or modify commercially-

LABCOM Responsibilities

LABCOM's role within AMC is analogous to that of a corporate research center within industry.

Manage AMC's corporate laboratories

- **Perform high risk investigations and technological forecasting to identify and evaluate future technology opportunities.**
- **Perform early technology base efforts in areas critical to Army future.**
- **Perform generic technology base efforts.**
- **Transfer technology to RDE centers for maturation and application.**
- **Provide responsive technical expertise to RDE centers and PMs.**
- **Manage the survivability function—foster the infusion of survivability technology into combat materiel.**
- **Manage specific programs and special projects of general application.**

Manage AMC's technology base*

- **Plan AMC's technology base program—establish investment strategies and program priorities.**
- **Oversee effectiveness of AMC's laboratory/RDE center system.**
- **Push maturing technology into system development via concept demonstration.**
- **Force technology transfer and integration within AMC.**
- **Support advanced systems concept and battlefield integration assessments.**
- **Provide independent technical evaluations.**

**** AMC-wide responsibilities of AMC Deputy Chief of Staff for Technology Planning and Management, a position assigned to Commander, LABCOM***

Figure 1.

available systems which meet essential requirements—nondevelopment items (NDI);

- conduct full system development, but expedite whatever opportunities exist (e.g., by using NDI components); and
- (with an eye on tomorrow) provide for future technology insertion in system design.

Even if shortcut strategies are infeasible and full development is the only recourse, the key materiel acquisition objective remains unchanged. The new procedure AMC will use to achieve this, as described in various *Army RD&A Magazine* articles during 1985, is commonly referred to as streamlined development. The RDE centers are being structured and staffed to implement and execute this new concept in system development.

A feature of the streamlined development process model is elimination of the demonstration/validation phase, with essential elements of this phase being accomplished in the tech base and proof-of-principle phases. This imposes a significant new responsibility on the RDE centers at the beginning of any given system development. The RDE centers must demonstrate the system is feasible and the technical and operational risks are acceptable before proceeding directly into the development and production prove out phase. The technology and operational concepts must be proven mature prior to Milestone I to avoid risk of slippage and cost growth during the development phase to finish a job which should have already been done. The development process must begin and remain a "winner" to meet the goal introduced above—reliable accomplishment without delay, disruption, or cost growth.

Technology Base Execution Functions

These considerations have a direct impact on the way AMC will execute the tech base effort. The resulting major steps leading to Milestone I are:

- identify and rapidly mature key technology,
- exploit technology from all sources,
- identify responsive system concepts,
- complete concept formulation planning,
- integrate technology into testable conceptual prototypes, and
- demonstrate prototypes in the hands of troops.

The roles and functions of AMC Headquarters, LABCOM and the individual labs, and the RDE centers are all being focused on making this process happen. (Note that the functions of RDE centers, as listed in Figure 2 track closely with these steps.)

Acquisition Functions of RDE Centers

For their commodities. . .

- **Know and understand the threat.**
- **Be cognizant of user concerns—maintain continuous dialogue and perform user market analyses.**
- **Maintain close liaison with PMs.**
- **Characterize battlefield environment of future systems.**
- **Define and analyze system concepts.**
- **Address human (MANPRINT), logistic (ILS), producibility, cost, and similar issues from inception of system conceptualization.**
- **Identify and exploit technology and system opportunities throughout the marketplace (academe, industry, other service/government—U.S. and foreign).**
- **Provide industry with IR&D and marketing guidance.**
- **Conduct market investigations to determine ability of current marketplace to meet system requirements.**
- **Orchestrate timely availability of essential technologies associated with emerging systems.**
- **Develop and mature commodity-specific technology.**
- **Integrate maturing technology into testable concept prototypes.**
- **Prepare concept exploration system planning and documentation.**
- **Demonstrate total system feasibility in hands of the ultimate user — field troops.**
- **Ensure technology is mature and total system concept is sound before beginning the development phase.**
- **If a PM is assigned for development, provide priority engineering support, including configuration management and engineering documentation, producibility and production engineering, and technical problem solving.**
- **If no PM is assigned, manage development and first buy.**
- **Support development of product improvements/block improvements.**
- **Provide life cycle engineering support of fielded systems.**

Figure 2.

Identify and Mature Technology

Key technology identification is one of the products of the mission area materiel planning and programming process. Jointly developed by the Training and Doctrine Command (TRADOC) and AMC, it systematically ensures that AMC's RDTE (6.1—6.7) funded programs are focused on the Army's most critical needs. The process begins with TRADOC's mission area analysis (MAA) of the future battlefield relative to current capabilities for each of its mission areas. The battlefield deficiencies identified in the MAAs are summarized and ranked by priority in the Battlefield Development Plan. The key materiel planning documents are the Mission Area Materiel Plans (MAMP). The MAMPs identify all ongoing or planned system developments or product improvements, the technology base programs necessary to implement them, and the time lines to achieve key milestones.

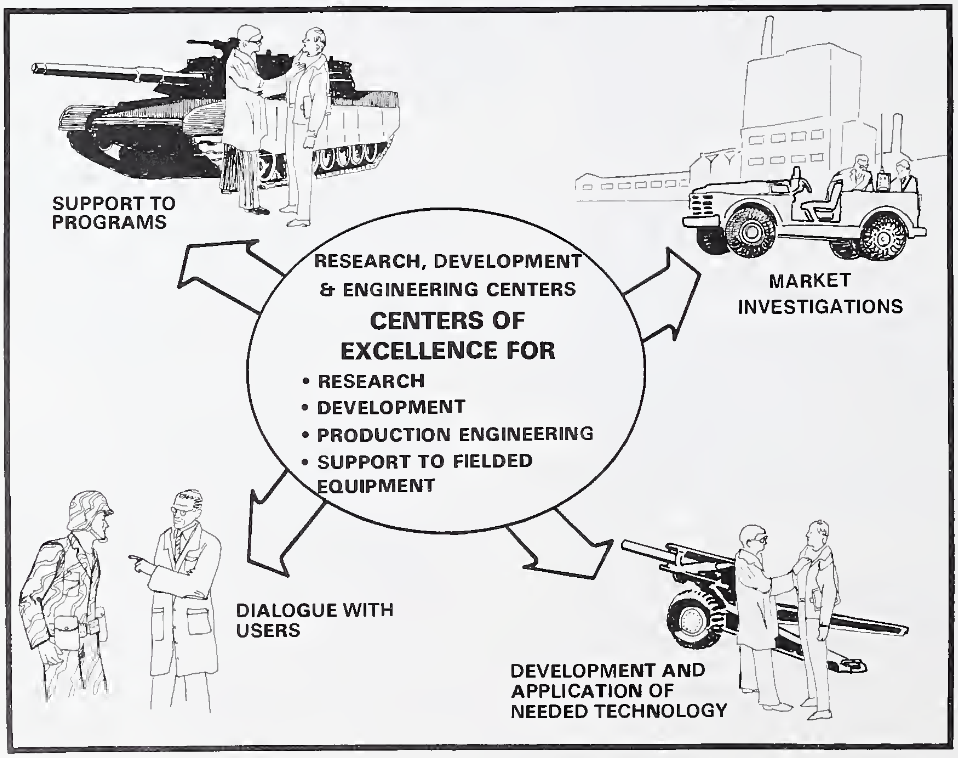
They also identify linkages to the critical battlefield deficiencies and the contribution the programs make to solving the deficiencies. Selected MSC commanders have been designated mission area managers responsible for preparing the individual MAMPs in coordination with TRADOC's centers and schools. The MAMPs are evaluated and integrated jointly by AMC and TRADOC Headquarters and by LABCOM for the tech base elements, forming the basis for the annual RDTE program review.

Exploit All Sources

Technology is matured not only by the labs and RDE centers, but also by universities, industry, other services, and other government agencies—both U.S. and foreign. Industry develops much of the needed technology in their Independent R&D Programs. Plans for this technology, just as those for AMC's in-house programs, are identified and fully integrated into the MAMPs. It is incumbent on LABCOM and the RDE centers to provide guidance to industry to let them know what efforts would yield the greatest payoff to future system development and, from an industry perspective, the best opportunities for product marketability. Both labs and RDE centers must know the marketplace well to be able to fully exploit all sources of technology. In addition, the RDE centers must be aware of the availability of systems and components for NDI and have the skills to be a "smart buyer." Market surveillance must be thorough and continuous and sound market investigations must be conducted whenever there is prospect for market exploitation.

Concept Identification and Formulation

An organizational element for planning and coordination has been instituted within each RDE center—the Advanced Systems Concepts Office (ASCO). Its focus is on the future within its commodity area. The ASCO's primary roles are to analyze, for appropriate time slices, operational considerations and interrelationships of commodity systems (current, improved, planned, and proposed)—this is the process of horizontal integration—and, in that environment, to identify and define viable, responsive system concepts. To execute these functions, the ASCO must know user market conditions and, using that information, conduct systems analyses. It is responsible for close liaison with the user community, knowledge of the threat, and knowledge of and planning for future system operational environments. This means forecasting logistics capabilities, manpower constraints, operational concepts, competing systems, associated equipment, and any other consideration projected to impact or be impacted by the downstream fielding of conceptual systems. Its products will be reflected in concept formulation planning and documentation.


SUPPORT TO PROGRAMS
RESEARCH, DEVELOPMENT & ENGINEERING CENTERS
CENTERS OF EXCELLENCE FOR
• RESEARCH
• DEVELOPMENT
• PRODUCTION ENGINEERING
• SUPPORT TO FIELDED EQUIPMENT
MARKET INVESTIGATIONS
DIALOGUE WITH USERS
DEVELOPMENT AND APPLICATION OF NEEDED TECHNOLOGY

Concept Prototypes and User Troop Demonstration

The mechanism for bridging the gap between technology development and system development is via a formal user troop demonstration. The LABCOM ASCO, in coordination with RDE center ASCOs, is responsible for identifying and selecting conceptual systems which are ready to be pushed out of technology and into system development. "Ready" means the concept fits, is responsive, and is sufficiently mature to be embodied in a user troop demonstration prototype. The demonstration will permit evaluation of prototype system concepts (and alternative concepts, if they exist) in realistically simulated battlefield environments in the hands of soldiers. Concepts will be tested and assessed for both developmental and operational issues impacting system development. If appropriate, some experimentation can be performed during this process. Exploratory programs will not pass Milestone I without demonstrating that technology is adequately developed and the operational concept is sound.

After Milestone I, system development management often shifts to a higher mode, to permit more concentrated management attention. If a high level of intensity is required, as for major systems, a PM may be assigned. Other systems may join an existing family of PM managed systems. However, the majority of system development efforts, typified by the class of non-major programs, are continued in the RDE centers. The management instrument may be a project engineer encumbered with several other responsibilities on up to a locally chartered development project officer with a small dedicated team to assist, depending on the level and type of management attention required.

Support the PM

Programs that are handed off to a PM are transferred out of the RDE center and into a PM office, normally reporting to the commander of the commodity command. Program hand-off to a PM does not complete the RDE center's (or lab's) role in its future development. To the contrary, the "full service" nature of the RDE center is just beginning. The RDE center and, when appropriate, the labs provide priority total engineering support to the PM in the development phase and production checkout. To do this, elements within the commodity MSC responsible for producibility engineering and for engineering support (including configuration management and engineering documentation) will be assigned to the RDE centers. Through all phases of development, close linkages must be maintained with the PMs and program support elements of the MSC—integrated logistic support, product assurance, cost analysis, systems safety, procurement, and others. When appropriate, dedicated cells of these elements and other operations support functions may be established within the RDE centers. The RDE center's responsibilities extend to all engineering functions which influence or document system design/configuration.

Research, Development & Engineering (RDE) Centers

Commodity Commands	RDE Centers
Armament, Munitions & Chemical Command	Armament RDE Center Chemical RDE Center
Aviation Systems Command	Aviation RDE Center
Communications-Electronics Command	Communications-Electronics RDE Center
Missile Command	Missile RDE Center
Tank-Automotive Command	Tank-Automotive RDE Center
Troop Support Command	Belvoir RDE Center Natick RDE Center

Figure 3.

The priority technical support and expertise provided to PMs by the labs and RDE centers duplicates capabilities formerly resident in many of the PM offices. Reassignment of these PM personnel to the respective RDE centers permits more flexible and efficient use of their skills. The PM offices then become lean, highly efficient core management functions. They will achieve requisite dedicated engineering capabilities by matrix management, tapping specialists from the RDE center and adjusting their makeup to correspond to current needs. Both the PM and RDE center must work together (supervised by the MSC commander) to ensure the PM receives needed support while avoiding excessive commitment of RDE center resources.

Future PM offices are "grown" in the ASCO. Pending major systems are likely to be managed in an ad hoc element of the ASCO operating in a pre-PM office mode, simplifying transition. Likewise, people associated with managing a conceptual system through concept demonstration and preparing it for Milestone I are the best candidates to continue with the system into development.

As systems progress to production and deployment and for the duration of their life cycle, the labs and RDE centers continue to support them. They frequently are called on for advanced technology for block improvements and equipment upgrade and to provide help in identifying and solving problems in fielded systems. Indeed, except for execution of the production function (normal operation of mature production lines), both the RDE centers and the laboratories have essential roles throughout the process of expeditious acquisition and engineering support of Army materiel.

Summary

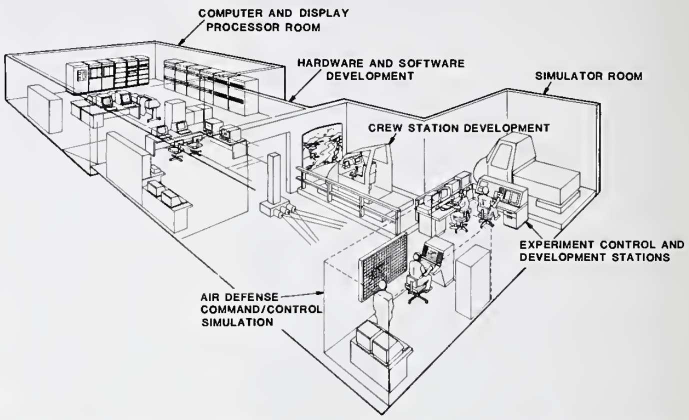
AMC's laboratory/RDE center system is in the implementation phase of an exceptionally dynamic organizational process. Corporate tech base entities and management functions have been consolidated into LABCOM (as discussed in a previous article). Eight RDE centers (Figure 3) have been organized within the commodity commands to consolidate their RDE function and resources into centers of excellence for their respective commodity. All these organizations have been structured to implement AMC's acquisition doctrine, which gives preference to product improvement and NDI and specifies a new streamlined process if full development is required. The critical acquisition functions of the labs and RDE centers have been clarified and initiatives to enhance their effectiveness have been (and continue to be) implemented. In short, AMC's acquisition and organizational structures have been tailored to streamline the acquisition process and rapidly integrate new technologies into our materiel systems.

DR. TIMOTHY M. SMALL is employed in the Office of the Deputy Chief of Staff for Technology Planning and Management, recently relocated from Headquarters, U.S. Army Materiel Command to U.S. Army Laboratory Command. He has participated throughout the Laboratory Improvement Program and is currently assisting in implementing its results. He has a Ph.D. degree in physics from Indiana University.

Human Factors Research Simulator

Computer specialist Philip Clark sits in the cockpit of a mockup helicopter at HEL. Simulated terrain, with obstacles the pilot must avoid while flying nap-of-the-earth, force the pilot to maneuver while performing other tasks.

HUMAN FACTORS RESEARCH SIMULATOR FACILITY


COMPUTER AND DISPLAY PROCESSOR ROOM
HARDWARE AND SOFTWARE DEVELOPMENT
SIMULATOR ROOM
CREW STATION DEVELOPMENT
EXPERIMENT CONTROL AND DEVELOPMENT STATIONS
AIR DEFENSE COMMAND/CONTROL SIMULATION

This high-performance, computer-based human factors research facility at HEL is designed for research into aviation and air defense issues. The facility includes computers, mockups, and control stations within three rooms.

A sophisticated system of computers integrated with helicopter mockups and simulators makes possible human factors research into complex aviation and air defense issues at the U.S. Army Human Engineering Laboratory (HEL).

The lab's research facility enables engineering psychologists and human factors engineers to simulate the tasks and workloads of pilots and crew members as well as soldiers involved in air defense. Researchers can gather data on human performance through simulated activity that will guide them in concept systems and evaluate the soldier-machine interfaces.

HEL, which reports to the U.S. Army Laboratory Command (LABCOM), planned the system over several years. It became operational in the summer of 1985. Called the Human Factors Research Simulator facility, it consists of host computers, display processors, crew station mockups, and control and experimenter stations in a three-room facility.

The simulator room contains a mockup of a generic helicopter crew station, a helicopter crew station simulator, a control and software development station for the researcher, and a mockup of a tactical operations center with a simulated large screen display.

The tactical operations center mockup is used for human factors research into air battle management related to short-range air defense. The generic helicopter mockup includes four display screens interfaced with the facility's graphics system. This gives researchers flexibility in evaluating a crew member's use of cockpit instrumentation.

Use of the mockup is enhanced by a low-cost, real-time digital terrain imaging system that uses commercially available graphics hardware. It presents the crew member with a simulated out-the-window view of the terrain. The terrain imagining gives the pilot a five-mile square area in which to fly. Trees, hills, rivers, bridges, tanks, flying helicopters, missiles, and other objects are all found within the area, objects that have been created and then stored in the computer as digital data.

A view of the terrain forces the pilot to maneuver while performing other tasks, including navigation, communication, and target acquisition. This enables researchers to analyze the pilot's workloads. The system can present as many as 20 moving targets, which also lends itself to human factors research in air defense.

In designing the simulator, the HEL staff considered the research issues that would come under evaluation. Some of the research issues identified in the aviation field were the display configuration in the cockpit, display content, data and graphics formats, methods of data entry (including voice and touch), and crew task allocation. Air defense research included crew station equipment configuration, display content and organization, and the effects of target saturation on air defense crews.

At the same time, researchers wanted to develop the Human Factors Research Simulator as a system that would support research over a broad range of human factors issues and provide a flexible system that can be easily reconfigured for quick turnaround on human factors research and development tasks.

Other objectives in developing the system were to provide an environment conducive to software development; to use off-the-shelf components; to keep the number of support personnel to a minimum; and to insure the availability of proven hardware, software, and commercially supported training.

HEL researchers are currently conducting air-defense studies related to the short range air defense system fire unit display concepts. Several aviation investigations for voice and manual data entry and map display concepts are underway to determine effects on flight performance.

U.S. Army Natick RDE Center

Making Things Better

> *"In the combat situation, the soldier not only faces the imminent danger of life, and more frightening for most, limb, but also witnesses combat wounds and death suffered by 'buddies.' Moreover, there are routine physical stresses of combat existence: the weight of the pack, tasteless food, diarrhea, lack of water, leeches, mosquitoes, rain, torrid heat, mud, and lack of sleep."— Charles C. Moskos Jr., "The American Enlisted Man," 1970.*

At the U.S. Army Natick Research, Development and Engineering (RDE) Center, Natick, MA, the above concerns are addressed by a dedicated and caring staff every day. They provide answers to questions that Army leaders ask in support of troops who will fight tomorrow's battles.

Some of the questions dissected by scientists, engineers, and other specialists employed at the center are, "What food does a battlefield soldier need when subjected to chemical, biological, or nuclear attack? What kind of body armor and camouflage can protect a person against fragmentation weapons, lasers, and camouflage-penetrating surveillance instruments? What temporary and battlefield hardened shelters can be provided? What airdrop systems can be developed to deliver supplies to deep strike forces, minimizing the vulnerability of the delivery aircraft?" In their microscopic examinations, these specialists not only provide answers to those questions, but sometimes uncover answers to questions not yet asked. How are they able to do this? First of all, it helps to understand the structure and a little history of the center itself.

Background

During World War I and II, the missions now at Natick were scattered throughout many states under the command of the Army Quartermaster Corps. In the early 1950s, the Army saw a need to consolidate these diverse functions into a single scientific complex. By 1952, operational centers in Indiana, Virginia, Massachusetts, Washington, DC, and Pennsylvania had moved to Natick. The consolidation plan was completed by 1963, and the group was named the U.S. Army Natick Laboratories. In 1983 it was renamed the U.S. Army Natick Research and Development Center, and became a subordinate command of the U.S. Army Troop Support Command, St. Louis, MO. Just recently, as a result of restructuring the U.S. Army Materiel Command's laboratories, it's name was changed to the U.S. Army Natick RDE Center.

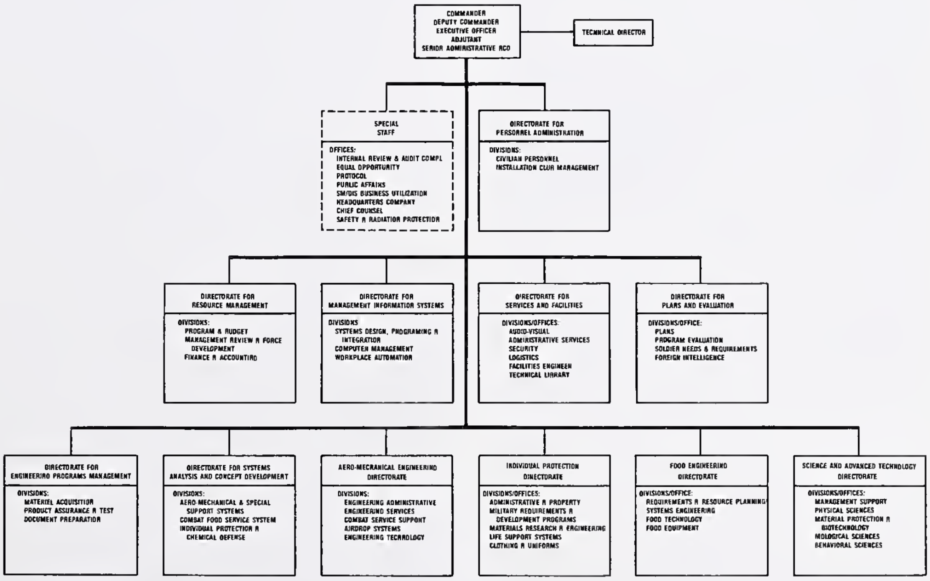
The center is divided into four separate directorates and several major support activities. An accompanying diagram showing the structure of the center gives some idea of what those support activities are. With no intention of minimizing their importance, this brief mention of those activities will have to suffice, in order to portray what one gentleman called, "those glory guys from the labs."

The four directorates (formerly laboratories) at the center are the Aero-Mechanical Engineering Directorate, the Food Engineering Directorate, the Individual Protection Directorate and the Science and Advanced Technology Directorate. But, indeed, it is "those glory guys" who transform those laboratories from cold, clinical institutions into warm and caring groups dedicated to protecting each of our individual soldiers.

Aero-Mechanical Engineering Directorate

"What airdrop systems can be developed to deliver supplies to deep strike forces, minimizing the vulnerability of the delivery aircraft?" This is representative of the kind of question that is answered here. This directorate designs and develops systems to airdrop personnel, supplies and equipment deep behind enemy lines.

MAJ Bruce A. Mercer, research and development coordinator, Aero-Mechanical Engineering Directorate, talks enthusiastically of the many programs undertaken by the directorate to increase airdrop accuracy and reduce aircraft vulnerability. Among them is the effort to increase the airdrop capacity to 60,000 pounds to take advantage of the


COMMANDER
DEPUTY COMMANDER
EXECUTIVE OFFICER
ADJUTANT
SENIOR ADMINISTRATIVE NCO
TECHNICAL DIRECTOR
SPECIAL STAFF
OFFICES:
INTERNAL REVIEW & AUDIT COMPL
EQUAL OPPORTUNITY
PROTOCOL
PUBLIC AFFAIRS
SM/DIS BUSINESS UTILIZATION
HEADQUARTERS COMPANY
CHIEF COUNSEL
SAFETY & RADIATION PROTECTION
DIRECTORATE FOR PERSONNEL ADMINISTRATION
DIVISIONS:
CIVILIAN PERSONNEL
INSTALLATION CLUB MANAGEMENT
DIRECTORATE FOR RESOURCE MANAGEMENT
DIVISIONS:
PROGRAM & BUDGET
MANAGEMENT REVIEW & FORCE DEVELOPMENT
FINANCE & ACCOUNTING
DIRECTORATE FOR MANAGEMENT INFORMATION SYSTEMS
DIVISIONS
SYSTEMS DESIGN, PROGRAMING & INTEGRATION
COMPUTER MANAGEMENT
WORKPLACE AUTOMATION
DIRECTORATE FOR SERVICES AND FACILITIES
DIVISIONS/OFFICES:
AUDIO-VISUAL
ADMINISTRATIVE SERVICES
SECURITY
LOGISTICS
FACILITIES ENGINEER
TECHNICAL LIBRARY
DIRECTORATE FOR PLANS AND EVALUATION
DIVISIONS/OFFICE:
PLANS
PROGRAM EVALUATION
SOLDIER NEEDS & REQUIREMENTS
FOREIGN INTELLIGENCE
DIRECTORATE FOR ENGINEERING PROGRAMS MANAGEMENT
DIVISIONS:
MATERIEL ACQUISITION
PRODUCT ASSURANCE & TEST
DOCUMENT PREPARATION
DIRECTORATE FOR SYSTEMS ANALYSIS AND CONCEPT DEVELOPMENT
DIVISIONS:
AERO-MECHANICAL & SPECIAL SUPPORT SYSTEMS
COMBAT FOOD SERVICE SYSTEM
INDIVIDUAL PROTECTION & CHEMICAL DEFENSE
AERO-MECHANICAL ENGINEERING DIRECTORATE
DIVISIONS:
ENGINEERING ADMINISTRATIVE
ENGINEERING SERVICES
COMBAT SERVICE SUPPORT
AIRDROP SYSTEMS
ENGINEERING TECHNOLOGY
INDIVIDUAL PROTECTION DIRECTORATE
DIVISIONS/OFFICES:
ADMINISTRATIVE & PROPERTY
MILITARY REQUIREMENTS & DEVELOPMENT PROGRAMS
MATERIALS RESEARCH & ENGINEERING
LIFE SUPPORT SYSTEMS
CLOTHING & UNIFORMS
FOOD ENGINEERING DIRECTORATE
DIVISIONS/OFFICE:
REQUIREMENTS & RESOURCE PLANNING
SYSTEMS ENGINEERING
FOOD TECHNOLOGY
FOOD EQUIPMENT
SCIENCE AND ADVANCED TECHNOLOGY DIRECTORATE
DIVISIONS/OFFICES:
MANAGEMENT SUPPORT
PHYSICAL SCIENCES
MATERIAL PROTECTION & BIOTECHNOLOGY
BIOLOGICAL SCIENCES
BEHAVIORAL SCIENCES

U.S. Army Natick RDE Center

cargo capacities of current and developmental Air Force Cargo aircraft.

An interim 42,000 pounds airdrop system will be fielded soon, which will allow the airdrop of a fully combat loaded M551 Sheridan Armored Reconnaissance Vehicle and the new family of Combat Engineering Equipment. Mercer says the directorate is also working on the Airdrop Controlled Exit System which links airdrop platforms together so whole systems such as weapons, vehicles and ammunition can be airdropped in a single load. This system greatly reduces dispersion on the drop zone and increases combat readiness.

Another agressive program will provide the Army with the capability to soft-land 5,000 to 60,000 pounds of cargo from a 300-foot altitude. Called the Low Altitude Parachute Retrorocket Airdrop System, it incorporates modified parachutes, an onboard microprocessor and retrorockets to provide a low altitude airdrop of heavy cargo and a soft-landing capability to eliminate requirements for time consuming rigging and derigging of cushioning material. This drastically reduces assembly time and provides a drive-on/drive-off capability for vehicles and weapons systems.

"What temporary and battlefield hardened shelters can be provided?" The Aero-Mechanical Engineering Directorate is also responsible for tactical shelters, tentage and organizational equipment. The recently fielded Army Standard Family of Tactical Rigid Wall Shelters conforms to international shipping standards so all modes of transportation can be used. Two versions are expandable to offer up to 450 square feet of live-in/work-in space. Each shelter can be fitted with specialized kits for electricity and environmental control. Adaptable for a variety of applications, these shelters are currently being used in Army, Navy and Air Force field hospitals, in aviation intermediate maintenance facilities and in Air Force mobile Tactical Operations Centers.

Mercer also speaks of an improved laundry system which has been developed through a Military Adaptation of Commercial Items program. This system provides 120 pounds of laundry per hour and reduces water requirements by 50 percent. Finally, a Laundry and Drycleaning Decontamination System, currently under development, will not be dependent upon water but uses a freon based system to provide drycleaning and decontamination of all washable items for field troops.

Food Engineering Directorate

"What food does a battlefield soldier need when subjected to chemical, biological or nuclear attack?" The specialists in the Food Engineering Directorate tackle this question and have the latest answers available. This does not mean, however, that they feel their task has been completed. They continually search for even better answers. Specialists are currently examining the packaging of food pouches to see if they can be penetrated by nuclear, biological or chemical contaminants. These food packets would be used by personnel in protective shelters.

For those soldiers not in a protected environment, but dressed in full Mission Oriented Protected Posture regalia, specialists are working on both the valve in the protective mask through which food and drink must pass and the actual food and drink to be consumed. Both the valve itself and the food and drink packaging must be able to prevent contaminant penetration. At this time, tube food, like that used in the Mercury space flights of the early 1960s, seems to provide the best solution. And consideration is being given as to what types of food and drink should be made available.

The above examples are but a few of the missions accomplished by this directorate. MAJ John B. Smith, chief of the Requirements and Resource Planning Office, is happy to recount other directorate success stories. He seems particularly proud of the wide acceptance of the center-developed Meal, Ready to Eat ration, but says the directorate is not resting on its laurels. Already the directorate is working on an improved Meal, Ready to Eat. In close cooperation with the troops who consume the goods, food engineering specialists are planning to, as Smith says, make a good thing better.

Tray Packs are another success story on which Smith is pleased to report. The basic building block of the new Army Combat Field Feeding System, also developed at the center, Tray Packs are hermetically-sealed, half-size steam-table containers which have been thermally processed, and can be transported and stored without refrigeration. They have received very favorable reviews from troops during field evaluations, but more variety has been requested. So, items such as lasagna (which could never be successfully canned) have been provided. In addition, a wide variety of breakfast items will be added to the menu.

Smith is quick to point out other items under development which have also received a high degree of acceptance, including the Ration Lightweight 30-day; the Food Packet, Assault; and the Arctic Ration. As mentioned earlier, not only does the center develop the rations themselves, but they also develop the means by which the soldier, either by himself or on a company or divisional unit level, can prepare and serve the meals.

Finally, the Food Engineering Directorate is seeking to minimize the types of cooking fuel needed in the field. For example it is working on a diesel-fueled burner. And since fresh bread is such a morale booster for field troops, Smith says a non-development item project is underway to provide a field bakery system that should be ready to test by fiscal year 1987.

Individual Protection Directorate

It is here in the Individual Protection Directorate that answers are provided for the question, "What kind of body armor and camouflage can protect a person against fragmentation weapons, lasers, and camouflage-penetrating surveillance instruments?" This directorate develops items which frequently touch soldiers' lives, in some cases, daily. Specific items include uniforms, protective clothing, personnel armor and life support equipment. All research, development and engineering concerned with the protection of the soldier is coordinated in this directorate.

The directorate is faced with the challenge of ensuring that its end items (footwear, handwear, clothing, canteens, load carrying equipment, sleeping gear, body armor and helmets) remain functional in climatic conditions ranging from arctic to tropic. In addition, these items must be resistant to chemicals, ballistic projectiles, flames, lasers, and advanced surveillance capabilities. Finally, the directorate must ensure that these items are sized to fit the wide range of Army personnel.

CPT James M. Kelsey, research and development coordinator/military assistant to the director of the Individual Protection Directorate, stresses that the center tries very hard to develop systems rather than piecemeal items. It is well aware of the effect one item has on an-

William C. Amico, Uniform and Pattern Branch, Individual Protection Directorate, uses a computer to take measurements from a cobbler's last. From that one last, the computer can size a shoe or boot for the range of sizes from infants to 15EEE.

other. Like the song that tells you, "The leg bone's connected to the hip bone . . .," each individual item this directorate develops can be part and parcel of a whole system. And the final product must meet all the rigid standards of protection and still be light enough and comfortable enough for a soldier to wear. The importance of cooperation between individual item developers here is quite clear.

Kelsey cites the example of the center-developed Integrated Individual Fighting System, which includes a Tactical Load Bearing Vest and a Large Field Pack containing a sleeping bag compartment. The vest and pack can be worn separately, or a portion of the field pack can be attached to the vest as a combat patrol pack. And, of course, the vest and pack can be worn together.

Other items Kelsey says are under consideration include a multi-purpose overboot for both chemical and wet weather protection, non-prescription ballistic protective eyewear, heated hand and footwear, a man-portable micro-climate cooling system, and the aircrew uniform, integrated battlefield, which provides both chemical and flame protection to pilots.

Science and Advanced Technology Directorate

The Science and Advanced Technology Directorate, although last to be discussed, is actually the first of the directorates to begin addressing current and projected future battlefield deficiencies. Using combined knowledge from the behavioral, biological, physical and engineering sciences, specialists from this directorate unravel the questions posed at the beginning of this article and seek possible answers. Using state-of-the-art technology, they project solutions to the projected threats of the battlefield of the future.

In the behavioral field, scientists strive to ensure soldier acceptance and compatibility with all Natick-designed products, equipment and systems. Soldier acceptance, in turn, will promote good morale and combat effectiveness under the hazardous and stressful conditions of a future battlefield.

In the biological area, work is carried out to prevent microbiological damage to military materiel and systems and provide the individual and small group the means to purify "pick up" water in the field when it is not possible for them to be supplied with potable water. Dr. Arthur M. Kaplan, chief, Material Protection in Biotechnology Division, is enthusiastic as he talks about the efforts taken to make certain that the material and systems upon which the soldier depends, maintain integrity and reliability in the face of potential damage by microorganisms. This is a formidable task when one realizes that almost every material can be damaged by microorganisms, such as textiles, leather, plastics, paper, wood, metal, glass, and electronic systems. He also notes that extensive work is being done to modify commercial items to meet military requirements for individual and small group water purification devices for NBC combat situations.

In the physical and engineering fields, one of the things scientists work to develop are measures for extending and estimating shelf life of rations. Kaplan tells of a machine they use to detect thermophiles, microorganisms that can withstand high heat, and how they have developed ways of processings foodstuffs to eliminate thermophiles. In addition, this directorate conducts the technological research for the development of fibers, fabrics, films and other polymer forms for protection against directed energy and other hazards on the integrated battlefield.

Summary

In the interest of time and space, the preceding paragraphs have only touched upon the many and varied projects undertaken by the Natick RDE Center. For every item discussed, there are untold others that in themselves would make a good story. The underlying priority that is clear throughout the center is the obvious concern for the soldier who will be using its end products. As one gentleman put it, "Our whole existence is about soldier survival on the battlefield," and it seems they do at times walk a mile in soldiers' combat boots. And when the center sees a need for improvement, we can find it busy at the task of making things better.

AATD'S Vibration Testing Facility

By Nicholas J. Calapodas

Historically, newly developed helicopters have encountered major vibration design problems which decrease operational capabilities and increase life-cycle costs. Helicopter vibration problems are extremely difficult to quantify and are usually solved during the development cycle by trial-and-error testing. A major reason for trial-and-error testing to solve vibration problems has been lack of definitive procedures which make maximum use of vibration test data.

During the past 10 years, in an effort to deal with vibration problems, the Aviation Systems Command's Aviation Applied Technology Directorate (AATD) at Fort Eustis, VA, has been engaged in vibration analysis and testing methodology. The objective is to develop and implement advanced technology which can be applied to vibration problems.

Recently, techniques have evolved that apply ground and flight vibration test data to measure rotor-induced vibratory loads, improve finite element models, and predict changes in vibration caused by structural modifications. These methods provide systematic, as opposed to trial-and-error, procedures for testing, correlating and evaluating helicopter vibrations.

In support of AATD's in-house research, a Vibration Testing Facility has been constructed that can accommodate helicopters up to the size of the UH-60 Black Hawk.

Helicopter Suspension Fixture

The suspension fixture for the new test facility was designed and fabricated in-house. The primary design requirements were that it be capable of conducting both static and dynamic tests, be free standing, and that all testing be performed without major rearrangement of its structural members. The fixture is configured with a rigid backstop structure, supported entirely on air bags, and includes an overhead structure that houses the aircraft suspension system. The design of a pneumatic system is under way that will provide low-frequency (less than one hertz) rigid-body response for helicopter gross weight ranging from the OH-58A to the UH-60A.

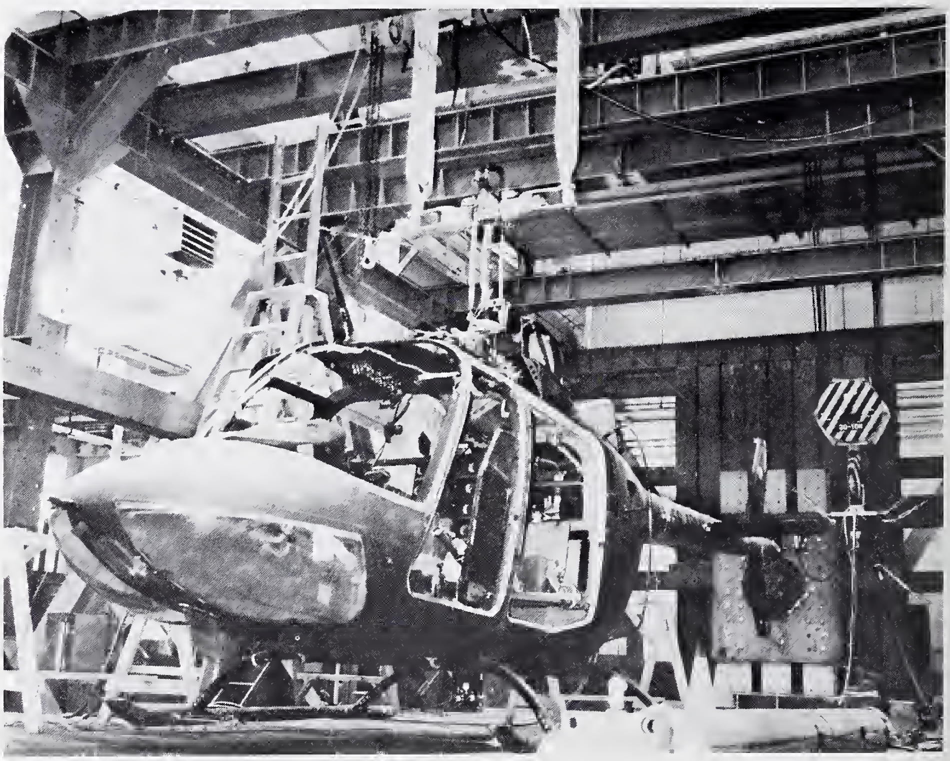
Data Acquisition System

The vibration facility's data acquisition system consists of function generators, controllers, exciters, signal conditioners, a multiplexer, storage media, analog-to-digital converters, and a processor that allows transducer output to be stored in the appropriate format. Function generators and amplifiers are available to control electromagnetic shakers for 650, 220, 100, and 50 pounds maximum force output for frequency range between five and 5,000 hertz. Sinusoidal, square wave, ramp, and random signal generation can be produced.

The available controllers can maintain constant exciter force, velocity, and acceleration output as the excitation frequency sweeps through the natural frequencies of the specimen. In addition, the controller can be programmed to have multiple frequency cross-over points of preselected excitation levels. Several function generators are also available to control hydraulic actuators ranging from 1,000 to 5,000 pounds force output.

Piezoresistive transducer output is routed through a bank of 60 signal conditioners configured with analog low-pass filters for 50, 100, 500, and 1,000 hertz frequencies. Charge amplifiers are also available to condition the output of piezoelectric transducers. The conditioned signals are input to a 64-channel digital multiplexer and can be stored on digital magnetic tape or hard disc utilizing software resident to a Hewlett-Packard 5451C Fourier Analysis System.

The analyzer is subsequently used for data processing and analysis. A new control system is under development using a processor that will control force and phase among eight exciters, a combination of hydraulic and/or electromagnetic. This system is required to perform "ground flying" for full-scale helicopter reliability testing.



Helicopter suspension fixture.

Data Processing

Central to the Vibration Testing Facility is the 5451C Fourier Analysis System. Utilizing software provided with the system and software developed in-house, multiplexed signals obtained during the data acquisition phase are extracted from digital magnetic tape or disc and are processed to develop transfer functions—the ratio of transducer response (output) to excitation force (input). The process involves demultiplexing time domain responses for the reference signal (usually, output of a load cell) and up to three selected transducers.

Because helicopter airframe vibrations are caused primarily by main and tail rotor excitations that occur at frequencies directly related to main rotor RPM, frequency domain data processing is convenient. Therefore, after demultiplexing the signals, a fast fourier transformation is performed simultaneously on four channels (reference and three response channels) of a given block size followed by power spectrum and transfer function operations.

In addition, a band selectable fourier analysis can be performed when narrow band frequency data are required. The in-house software package employs the above algorithms in an interactive fashion which allows the operator to specify the number of transducers to be processed, the frequency band, number of averages, and file number on the hard disc to store the resulting transfer functions and coherences.

Currently, the system is configured to process up to 56 channels at 256 block size of 28 channels and is a lengthy operation. However, the process is automated and can be performed without the analyst's attendance.

Data Analysis

All analysis software resides on the Real-Time Executive (RTE), version 4B, of the 5451C system. The RTE allows the processor to be used as a stand-alone system with the capability to execute FORTRAN programs. The 1000E series processor of the system is configured with 256K words of memory. A preprocessor program, developed inhouse, allows sequential extraction of transfer functions from which dynamic properties of the test specimen are obtained. These properties become input to analysis software suitable to meeting specific objectives, such as, modal determination, structural modification, vibration absorber/isolator placement, and hub loads determination.

A Structural Modal Analysis Research Tool software package incorporates a curve fitting algorithm for extracting the natural frequency, modal damping, and orthonormal modes from responses exhibiting classical or complex behavior. Also, the analysis provides the capability to reconstruct the transfer function based on the modal properties previously extracted and serves to check the quality of the modal analysis.

In recent years, the finite element methodology has been used to develop airframe analytical models that guide the static and dynamic design during the preliminary and detail design phases of a new helicopter development or major modification of an existing system. The accuracy of the finite element dynamic model is substantiated by means of ground vibration testing (shake test). However, once the prototype is constructed, scheduling becomes highly compressed and detailed correlation of the analytical model with the prototype is pushed further down the development cycle. Therefore, if a vibration issue arises during ground testing and structural changes are required, reliance on the analytical model is limited.

The availability of new analytical tools, that make use of ground vibration data and allow a designer to make airframe analytical changes easily, would enhance the design effort. At AATD, several such analytical techniques are being investigated or are under development. A structural modification analysis is undergoing correlation with helicopter data. This analysis will make use of baseline ground vibration data and will allow a designer to make numerous airframe analytical mass and stiffness modifications quickly and predict the new natural frequency (or frequencies).

Another analytical tool known as analytical testing is undergoing correlation. This analysis uses ground vibration data and baseline flight test data, and it allows a designer to predict new flight responses due to mass or stiffness changes of the airframe or placement of vibration absorbers. For example, flight responses can be predicted at selected points on the airframe due to the addition of rocket pods, external fuel storage, etc.

A third major analytical tool, known as force determination, has already been verified on the AH-1G and is currently being refined. This technique allows determination of hub loads (shear forces and moments) based on ground vibration and flight test data. It requires considerably less instrumentation than what is customarily used, has a high degree of accuracy, and nominal computational time. Other methods that will be investigated or developed in the near future encompass finite element model correlation work, multipoint excitation, and couple rotor/airframe analysis correlation.

Conclusion

Invariably, new helicopter designs experience vibration problems that require special treatment to comply with design specifications. Usually, those problems are quantified during the flight test phase and resolution is costly and delays production schedules. A systematic combination of test and analysis that allows a designer a range of solution tools would be cost effective.

AATD has an active interest in vibration technology enhancement, and a ground vibration testing facility has been constructed. The ground vibration testing capability is augmented by AATD's capability to conduct experimental flight testing of limited scope. The development of this facility coupled with the flight test capability allows the performance of research programs to enhance the state of the art of dynamic design and testing methodology.

(Editor's Note: See Page 27 for more on solving rotor dynamics problems.)

NICHOLAS J. CALAPODAS is the project engineer for the development of the Vibration Testing Facility and has been employed at the Aviation Applied Technology Directorate, Fort Eustis, VA, since 1974. He holds B.S. and M.S. degrees in aerospace engineering from the University of Kansas and has conducted post graduate work at Old Dominion University, Norfolk, VA.

The AAWS-M Acquisition Strategy

By COL Robert T. Walker

The Army staff and its senior leadership recently approved a commitment to develop a new generation of infantry anti-tank weapons to meet the needs of soldiers in the next decade. Secretary of the Army John O. Marsh Jr. has approved a decision of the Army Systems Acquisition Review Council to begin development of a one-manportable anti-tank weapon currently called the Advanced Antitank Weapon System—Medium. This weapon, known by the acronym AAWS-M (pronounced AWESOME), has been desperately sought by the infantry to replace the aging Dragon missile system.

The AAWS-M is intended to provide infantry soldiers of the 1990s the capability to defeat advanced design tanks and other armored vehicles expected to be deployed in large numbers by the Warsaw Pact nations. The acquisition strategy for the AAWS-M development program is intentionally structured to allow for potential expansion of the design concept into a larger, heavier and more robust version (a "Heavy" or AAWS-H version) utilizing common technology if industry proposals appear to offer such growth potential with acceptable technical risk.

The AAWS-M program approved by the Army includes an innovative acquisition strategy that emphasizes competition in contracting in both development and production, provides for selection of the guidance technology based, in part, on a "shoot-off" style hardware demonstration rather than a paper analysis and allows for completion of operational testing by soldiers prior to any commitment to production.

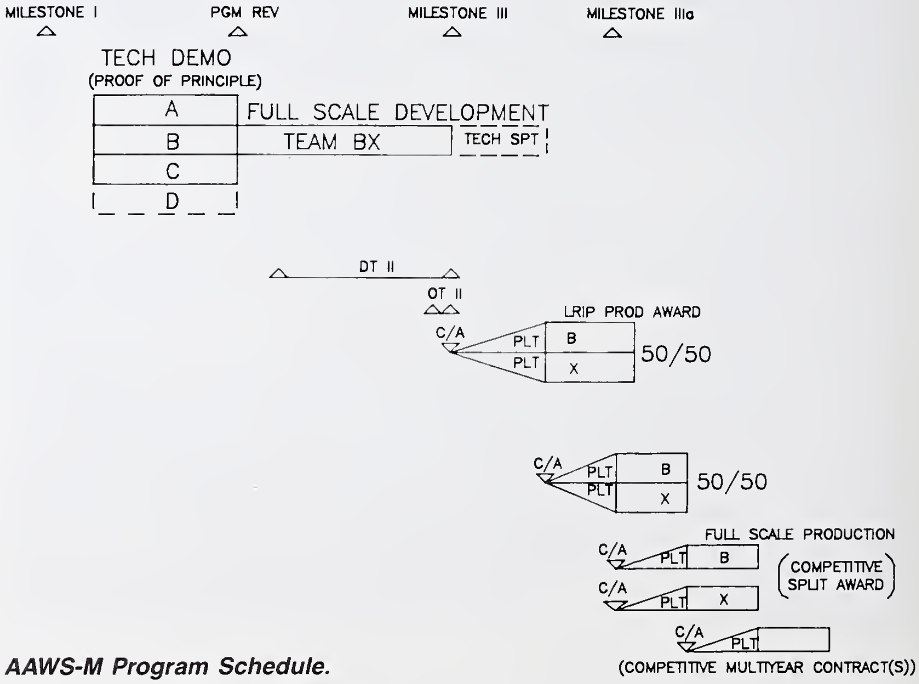
Technical analysis of the AAWS-M performance requirements requested by the U.S. Army infantry showed that several promising technical approaches were available to guide the missile to the target. Some of these concepts have been demonstrated by defense contractors in prototype form and have been seen in demonstrations and briefings. These industry demonstrations parallel similar advanced development work in government R&D centers.

Actual start of the AAWS-M program begins with a full and open competition between industry bidders for technology demonstration contracts which will last for two years. This phase of the program will include competitive test and evaluation of alternative designs for guidance systems and warheads. The Army plans to award three or perhaps four contracts for the technology demonstration phase of the the AAWS-M program if the proposals received from industry are determined to be responsive to the Army's defined needs.

In the accompanying illustration, it is assumed that four contractors (identified as A, B, C and D) receive contracts to build and deliver missiles, launchers and other hardware which will be delivered to government facilities for test and evaluation. During this period of testing, the competitors will be required to propose to the Army their plans and costs for completing full-scale development of their designs. During this period of competition, they will also be required to quote production prices for the initial years of production.

The Army plans to have visibility of technical performance, development costs and production costs prior to selecting which contractor is the winner of the shoot-off phase.

Each competitor in the technology demonstration phase of the AAWS-M program will be required to join with a "teammate" as part of their proposal for the remainder of development and initial production. This teammate (identified as X in the illustration) will be another industrial firm having the capability to produce the developed design in the production phase of the program. The winning team will then enter a 36-month full-scale development phase to complete engineering design work and production plans. They will build several hundred missiles for a comprehensive test and evaluation. This test phase will include Manpower and Personnel Integration evaluations; reliability, availability and maintainability requirements demonstration; accuracy and lethality tests; and formal Operational II Tests by soldiers and Marines. Each teammate will build half of the test hardware to assure that both firms involved in the program have the capability to build AAWS-M missiles with



AAWS-M Program Schedule.

AAWS-M will replace the aging Dragon (shown here) which has been in the Army inventory for more than 10 years.

the required levels of performance and quality.

After analyzing the results of this test phase, the Army will then determine if the developed AAWS-M is suitable for deployment to soldiers in the field. If the AAWS-M design fills the needs of combat soldiers, the Army will enter the production phase of the program with two qualified production sources. The teaming strategy will result in industry competition for production of the system early in the production run while sizeable quantities of missiles remain to be built.

This approach is considered preferable to a leader-follower strategy which has been used in some past programs. In leader-follower strategies, the time required to develop the follower into a credible competitor to the leader is somewhat self-defeating since a significant portion of the production run may already have been built by the leader in non-competitive contracts. The emphasis on competition is expected to reduce program costs as well as respond to the direction of the Congress to increase competition in contracting.

Following the initial production, which will be procured from the team, the team will then be split and each teammate will become a competitor in the production phase of the program. The Army at that point will have several alternatives for production competition strategies, including keeping both producers in production and competing them on price or going for a winner-take-all multi-year buy out of the production run.

The AAWS-M acquisition strategy of technology selection, based on competitive hardware evaluation, requiring teaming in full-scale development, and starting production with two qualified producers, provides competition at the start of development, midway through development and early in the production phase. Army planners expect this approach to provide:

- reduced technical risk by "flying before buying,"
- lower costs in both development and production, and
- reduced schedule risk as a result of the early competition in development and availability of resources from two firms which can support the later phase of development.

The approved AAWS-M program is the culmination of a series of aborted attempts in recent years to begin development of a successor to the Dragon which was originally fielded in 1975. The earlier proposed Dragon replacement programs, variously known as the Advanced Medium Antiarmor Weapon System, the Infantry Manportable Antitank Assault Weapon System, and Rattler, failed to gain the necessary support because of a lack of agreement on required performance characteristics and a perception that available technology could not provide the desired accuracy and lethality within the desired system weight.

The infantry has been dissatisfied with the Dragon design because of its limited of range, accuracy and lethality and because of the training burden required to maintain proficiency of Dragon gunners. The Required Operational Capability statement for AAWS-M prepared by the U.S. Army Infantry School, as the user representative, specifies a need for a manportable weapon, operable by a single soldier, having significantly extented range compared to Dragon, and lethality against advanced design armor protection.

According to the infantry, manportable means a weapon that weighs no more than 35 pounds. However, the infantry is willing to consider an AAWS-M system weight up to 45 pounds as long as other performance features are included. The AAWS-M will be required to perform in severe fog, smoke and other obscurant or counter-measure environments, and provide high reliability along with a low level of maintenance burden.

The Army Materiel Command is now preparing to begin development of the AAWS-M using an acquisition strategy that includes new innovations to emphasize competition, reduce program risks and minimize program costs. The goal of the program is to provide soldiers of the next decade with a modern, lethal antitank weapon that will significantly increase the combat power of our fighting forces.

COL ROBERT T. WALKER is commander of Watervliet Arsenal. He authored the preceding article during a former assignment as project manager for Advanced Manportable Weapon Systems. He has a B.S. degree in mechanical engineering from the University of Akron and a master's in industrial management from George Washington University.

Camoufla
Thermal I
Signatur

By Dr. Ashok S. Patil

Background

The thermal infrared (IR) signatures of military field equipment are of increasing concern as technology becomes available to detect these units at aircraft or satellite ranges.

The threat of surveillance in thermal IR wavebands by line scan techniques has existed for many years; however, advances in recent years have led to imaging techniques that give high quality images in real time. Such thermal images resulting from forward looking infrared systems may be used for both surveillance and target acquisition systems from either the ground or the air.

The Belvoir Research, Development and Engineering Center (BRDEC) has been designated as the Army's lead laboratory for camouflage and deception. BRDEC, an RDE center of the U.S. Army Troop Support Command, executed a comprehensive countersurveillance program in the Combined Arms Support Laboratory. The objective of the program is to significantly increase the effectiveness of radar and thermal signature suppression techniques for application to combat systems in general.

BRDEC is involved in several programs to support IR signature reduction techniques to enable the defeat of highly sophisticated sensor and seeker systems that operate in the thermal emission regions of three to five and eight to 14 micron wavelengths. The standard U.S. Army lightweight camouflage nets provide good protection in near IR (<1.0 micron); however, the effectiveness of these nets at longer wavelengths is very limited. The objective, therefore, is to develop an effective multispectral camouflage system that would suppress thermal infrared signatures of tactical targets to an ambient clutter level. This will result in denying the enemy the ability to differentiate between Army targets and the natural background.

There are two thermal IR "windows" where radiation from objects can be transmitted thru the atmosphere, at three to five and eight to 14 microns. The former waveband is known as "intermediate IR" and the latter as "far IR." The far IR enables much clearer imaging of objects which are close to the ambient background whereas the intermediate IR region is used when the object is much hotter than the surroundings such as hot exhaust pipes. Thermal radiation is emitted by a body as a result of its temperature and as the temperature increases, the body emits energy at a shorter wavelength.

Detection

The energy level of very hot bodies is much higher in three to five microns compared to warm bodies which emit most of their energy in eight to 14 microns. Far IR detectors need to be cooled, normally by liquid nitrogen, whereas intermediate IR detectors are cooled by ambient air. Thermal imagers are attractive for surveillance and acquisition systems because they provide good quality images. They can "see" day or night and have better haze or mist penetration than visual devices because of the longer wavelengths.

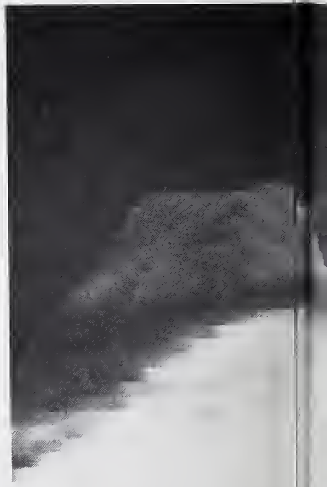
With the currently available optics and imaging technology, the angular resolution of a picture element in tactical systems is about 0.1 milliradians. An object of one meter size would fill the field of view of the picture element at 10 kilometer range and partially fill it at longer ranges. Detection of an object depends on the difference in radiant energy falling on the picture element presenting the hot object compared to that of the adjacent elements representing the background clutter. Detection and recognition of a target not only depends on background, but also on range and weather conditions.

Since 1977, the thermal signatures of several types of operating and non-operating gasoline, diesel, and turbine powered generators and other targets under different background environments have been measured and analyzed. Survivability goals have been developed based on these signatures, and analysis of a forward looking infrared radar's ability to discriminate between target and background at operational ranges. These goals provide the effective radiating temperature of a target and its emissivity as seen by the sensor in terms of a temperature differential target temperature and the natural background.

Suppression Techniques

As follow-on work, research efforts are under way to develop various suppression techniques such as low emissivity paints/coatings, thermal reflectors, and camouflage nets with thermal capability. The thermal emissivity of Army standard camouflage paints is limited by the emissivity of the paint binder which is about

A visual image of the test set up shows the c
and the bare generator on the right. Thre
foreground. These blackbodies are used t
images.



A thermal image of the s
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rate the resulting thermal

test set up shows the relative difference in
field of view. White is hot, dark is cold. Both
t the hot side faced the thermal sensor. From
tively determine the worth of the camouflage

0.95. There are many relevant thermal backgrounds where thermal emissivity is much lower than this. In order to achieve a lower emissivity it is necessary to use a different binder or use some highly reflective particles in the paint so that the overall emissivity is lowered.

Efforts to develop a multi-layer camouflage net material have been initiated. This concept will use frequency selective surfaces for IR performance that would be transparent in radar frequencies but reflective in infrared band. The objective of the program is to design multi-spectral materials that are effective across the entire electromagnetic spectrum. Recent developments in semiconductor polymers have led to materials with frequency dispersive conductivities and temperature dependent IR emissivities. A fabric or coating with appropriate pigments could be tailored to emit a similar power from the the hot or cold target as the background within the specified wavelength regions.

Another concept being developed is the use of a highly reflective layer close to the target so that the radiant energy is contained and then released through aeration. The objective of all these programs is to lower the emitted energy of tactical targets to a clutter ambient level.

Thermal Image Analysis

In support of these programs, the in-house measurement capability plays a key part in the overall research efforts. This comprehensive thermal analysis capability is provided by a facility that consists of both hardware and software. The hardware employed includes the Inframetrics 210 thermal imager and the infrared video system image processor. A software program developed in-house is designed to reduce thermal image data, in the form of video recording, to quantified thermal information. This enables us to digest a large quantity of data in qualitative as well as quantitative comparison of target and camouflaged target versus background. The results of this technique are verified for accuracy by taking data with thermocouples and radiant temperature measuring devices such as a thermopointer.

Thermal image analysis capabilities are complemented by spectral measurement facilities which span the ultraviolet, visible, and infrared regions of the electromagnetic spectrum. A Beckman dual-beam integrating sphere spectrophotometer, operating from 0.02 to 2.5 microns, is utilized to characterize the reflectivity of a camouflage material in the visible and near IR.

The Nicolet Fourier Transform Infrared (FTIR) Spectrometer determines a sample's infrared reflectivity/emissivity at each wavelength in contrast to the imaging system which integrates radiated energy over a broad wavelength band. The FTIR instrumentation, operating from 2.1 to 26 microns, permits a large number of spectral scans to be averaged in a short period of time thereby increasing signal-to-noise ratio and measurement accuracy.

The variation in thermal emissivity with viewing angle, the sophistication of multi-channel IR sensors and the complex interrelationship between targets and their thermal contrast to a wide variety of backgrounds makes thermal signature suppression a formidable task. Therefore, it is vital that these thermal imagers, spectral measurement instruments, radiant and kinetic temperature measuring devices and the data reducing software all be used to realize this goal. These tools provide the means to not only evaluate, but enhance thermal camouflage capabilities.

The goal of this research and development effort is to provide the Army with a camouflage system capable of concealing U.S. forces from hostile detection by defeating sensors that operate across the entire IR frequency range.

DR. ASHOK S. PATIL is chief, Camouflage Research Branch, Combat Engineer Directorate at the U.S. Army Belvoir RDE Center, Fort Belvoir, VA. He received his B.S. from Utah State University, his M.S. from the University of Virginia, and his Ph.D. from George Washington University. He is a member of the American Society of Mechanical Engineers.

PM/Materiel Systems Assessment Program

In his article in the AUSA 1985-86 Green Book, Army Vice Chief of Staff GEN Maxwell R. Thurman discussed a revolution that began in the mid-70's and continues today. The revolution GEN Thurman was referring to was the "bold reorganization" of the Army in 1973, the formation of 16 divisions (an increase from 13⅓) and the marriage of the combat development process and the Army school system. This modernization of the Army is almost half over and combat-capable, modern, mechanized equipment is rolling off American production lines into the hands of troops. In the same issue of the Green Book, Army Chief of Staff GEN John A. Wickham urges Army leaders to be good stewards of their resources.

Commanding General of the U.S. Army Materiel Command (AMC) GEN Richard H. Thompson has aggressively pursued his stewardship role and adopted ambitious new goals for timeliness and efficiency in development, production and fielding of weapons, equipment, spare parts and supplies. He has stated that paramount among the challenges facing AMC is providing quality and effective products to our soldiers when needed, at the least possible cost to the taxpayer. One of his ongoing initiatives to assist in meeting these challenges is the PM/Materiel Systems Assessment (PMSA) Program.

The PMSA Program was developed for all program, project, product managed systems as well as for other selected high visibility systems. The purpose is to have a more proactive technique that identifies potential system problem areas early enough in the life cycle process to initiate changes before they impact on fielding and sustainability.

In late October 1984, the AMC CG directed that a more effective and meaningful review technique be developed. A meeting was held between HQ, AMC and representatives of AMC's Major Subordinate Commands (MSC) and a "strawman" PMSA package was established to help facilitate future discussion and planning. By early February 1985, a firm agenda, chart formats and essential data requirements were finalized and, in late February 1985, Mobile Subscriber Equipment/Army Tactical Communications Systems PM COL Jim Frick presented the first PMSA to the AMC CG using the AN/TRC-151/152 radio system. The PMSA was very successful and was designated as the HQ, AMC review technique for weapons and equipment replacing the Command Review Program. On April 1, 1985, the CG released a message formally tasking PMs to develop PMSA packages for their systems and MSC commanders to develop PMSA packages on selected high visibility materiel systems.

The PMSA package is comprised of five sections: an agenda, a planning phase, the review itself, execution, and a miscellaneous problems section.

An agenda is the road map that is followed to focus on the ability of the PM or item manager to field units. The planning phase attempts to capture those events which, if not done correctly, will prevent system fielding or cause serious problems in the fielding process. The review is used to describe the system to include: Associated Items of Support Equipment, provide a historical perspective of where and how the system has evolved, and to outline the challenges facing the program or item manager. In the execution portion of the PMSA package, the actual fielding execution is examined in finite detail and reviews not only the production and inventory of the actual system being fielded, but also the tools, test equipment, spares and repair parts, publications, ammunition and petroleum/oil/lubricants. The final section of the PMSA package includes those elements which may not necessarily prevent fielding if a problem occurs but will cause severe difficulties.

The PMSA package has been designed with built-in checks and balances. Many relationships between charts are brought out in the methodology but become far more apparent only after familiarization with the PMSA Program. The relationships are used to determine the validity of the data being presented and as a double check of the data provided by different sources for different charts.

An "Issues and Actions" chart is the PMSA method of identifying problems and the actions recommended for their resolution. An issue is identified when there is a disconnect between what is programmed and what is actually occurring (or is anticipated to occur unless some action is taken).

The PMSA program normally follows an established briefing progression:

- Action Officer's Work Session: This session, chaired by the PM, is a preliminary meeting of all matrix functional personnel to review initial inputs (including recommended issues/actions) for clarity, validity and consistency. The preparers of the charts are present to answer any questions as to the data source or preparation and make any changes required after discussion by the principals involved. In addition to the PM and matrix personnel, other action officers such as the Force Integration Staff Officer and Weapon System Staff Manager (WSSM) may be invited at the PM's discretion.
- Council of Colonels/Directors: This council receives the first formal briefing of the PMSA package. All internal and external points of contact are invited. The council is usually chaired by a colonel. At this meeting, issues/actions may be generated, revised or deleted, and notes may be added or dropped. Issues/actions agreed to at the meeting may not be changed or deleted except by the next higher review. Following the review, point papers are written for each issue in the package. These point papers are forwarded with the PMSA package to the MSC and/or AMC Review.
- Major Subordinate Command Review: This review replaces the Command Review. Issues/actions are further defined, deleted or added at this time. Following the review, taskings are given to the proponents for resolution and the entire PMSA package updated quarterly.
- AMC Review: The commander of AMC currently has a "no notice" policy for PMSA Reviews. The PM must be prepared to brief the package with little or no prior notice. Those system managers with scheduled review dates are notified as to the number of seats available and may request any attendees they wish.

While the PMSA is an AMC program, the management team includes members from the HQDA staff, TRADOC, and other major commands working together to identify problems, assess impacts, and develop resolutions.

The WSSMs are the key players in the PMSA process and they are expected to use it as a management tool. WSSMs provide whatever assistance necessary to PMs including identification and follow-up of issues and actions, development of the PMSA presentation and analysis of data.

The PMSAs that have been reviewed at HQ, AMC thus far have been successful. We are telling a more accurate story, identifying issues in a proactive manner, solving some tough problems, and ultimately improving soldier support.

The preceding article was authored by LTC David T. Morgan, chief of the Office of Project Management, HQ, Army Materiel Command.

Engineering For Transportability

By CPT(P) Barry M. Ward

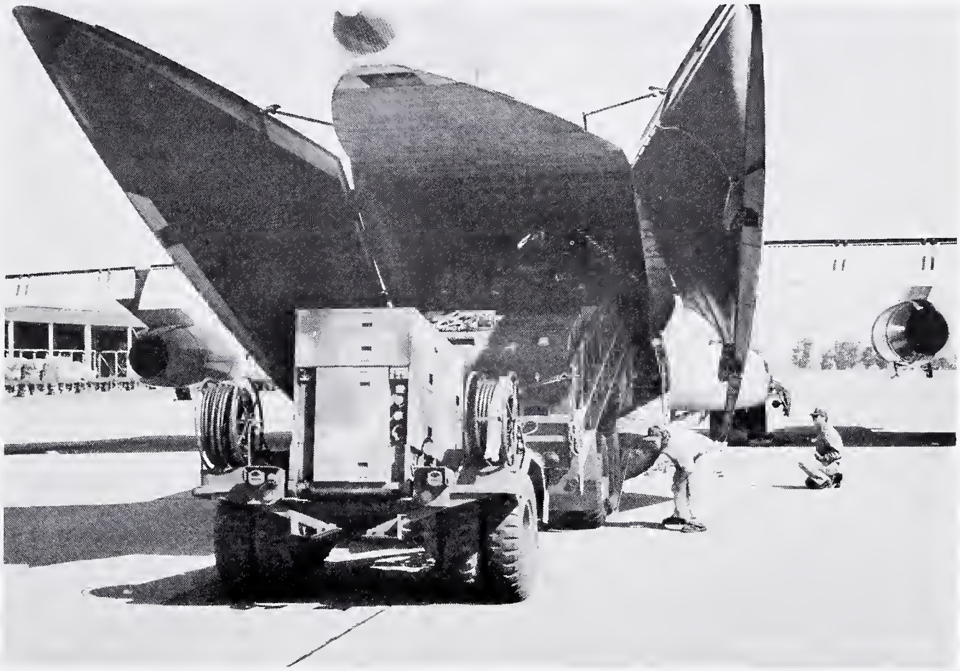
Background

Not so long ago, the Army inherently believed in the notion that "bigger is better" when it came to the design and development of new systems. After all, the historical trend has shown that new systems are often larger and heavier than those they replace. It is becoming increasingly apparent however, that this kind of thinking is changing. This change in our thinking has resulted from the recognition that bigger is only better if it is balanced with deployability requirements. In other words, if our weapon systems and equipment cannot be easily transported and quickly deployed into combat by existing and available transportation assets, then bigger is the evil of better.

When asked what he had in mind regarding downsizing equipment to enhance deployability during an interview with *Army RD&A Magazine* published in the November-December 1984 issue, GEN Maxwell R. Thurman, Army vice chief of staff, emphasized that the Army must change its thinking on the notion that bigness is good. He stated, "The Army must get things slimmed down. One way to do that is to write contracts that place a premium on smallness. NASA understands how to do this. They want miniaturized components because extra size and weight for them is very expensive. So they get it small.

"We [the Army] don't have that notion," GEN Thurman continued. "Our notion is, gee whiz, let's get the Navy to drive up six more ships, get the Air Force to drive up another 10 airplanes and we'll somehow get all that stuff deployed. We can't afford it. We have to think small."

And we have to think transportability. Equipment must not only fit into existing airlift and sealift cargo compartments, it must also be easily handled, loaded and tied down, as well. We can no longer afford to design, procure, and field weapon systems and supporting equipment to find out later the systems cannot be easily and quickly transported into combat.



RPV Test Loading

The Remotely Piloted Vehicle with its support equipment is being loaded onto a C141 aircraft during test loading at Travis AFB, CA.

However, because of an excellent team effort currently ongoing between the Army Materiel Command (AMC), the Training and Doctrine Command (TRADOC), and the Military Traffic Management Command (MTMC), much progress is being made toward reversing the "heavy-up" trend and improving the emphasis transportability gets as a design consideration. But credit must be given to the leadership at the top. GEN Richard H. Thompson, commander of AMC, GEN William R. Richardson, commander of TRADOC, and MG Harold I. Small, commander of MTMC, have joined forces to beat down transportability issues and to ensure their initiatives are fully integrated.

GEN Thompson has institutionalized a program within AMC to emphasize transportability engineering throughout the design and development process. GEN Richardson is ensuring that the language used in requirements documentation strengthens and clarifies transportability requirements and that the next iteration of Mission Area Analysis will continue to analyze both the strategic and tactical deployability of equipment on the battlefield. MG Small has moved forward with several initiatives to bring a better understanding of the Engineering for Transportability Program and transportability engineering technical assistance to both the materiel and combat developer communities. This article will focus on these initiatives to include actions taken and planned to enhance strategic mobility.

AMC Transportability Review

During the past several years, the Army has placed much emphasis on the need to enhance and effectively integrate transportability engineering throughout the acquisition and product improvement process. Recently however, several serious transportability problems have surfaced in the develop-

AMC Transportability Review

Summary of Findings

- **70 Hardware Systems**
- **Hardware Systems having Significant Transportability Shortcomings: 23**
- **Transportability Addressed in Acquisition Documentation: ***

	Adequate	Inadequate	None
Requirements Documents	40 (65%)	18 (29%)	4 (6%)
Contractual Documents	38 (61%)	11 (18%)	13 (21%)
Test Planning Documents	36 (58%)	5 (8%)	21 (34%)

** Documentation was available for evaluation of only 62 systems.*

- **Coordination with MTMCTEA:**
  Requests for Transportability Approval Submitted: 47 (67%)
  Total Transportability Approvals Granted: 22 (31%)**

*** 15 of the 22 were granted with restrictions and/or waivers.*

ment of new equipment, procurement of nondevelopment items, and the improvement of equipment already fielded. In each instance, the transportability process was bypassed.

Based upon the apparent need for AMC improvement in the transportability engineering process, a transportability review of selected systems in development was initiated. The AMC Transportability Review was conducted January 4 through March 22, 1985 and included a comprehensive look at 70 hardware systems representative of each of AMC's commodity commands. It covered all modes of transport, including rail, highway, marine, air (fixed and rotary wing), containerization, and lifting and tiedown provisions.

A review team was organized comprised of personnel from AMC Headquarters, the AMC Materiel Readiness Support Activity, and the Military Traffic Management Command Transportation Engineering Agency (MTMCTEA). The review team conducted site visits to each of the system project offices in order to gain information needed for the review. The review team's mission and primary objectives were to:

- discover problems with each system that adversely affect strategic mobility,
- uncover specific hardware shortcomings in the area of transportability engineering, and
- develop long-term recommendations to institutionalize engineering for transportability in the materiel design and development process.

Findings

The review team made 16 general observations which were characterized as systemic engineering for transportability problems or weaknesses common throughout the design and development process. The accompanying figure summarizes some of the more significant findings and observations discovered during the transportability review. It is important to note that transportability documentation was a significant weakness leading to many of the hardware shortcomings and the breakdown of the transportability engineering process. The absence of adequate early coordination with the MTMCTEA transportability engineers by both the combat and system materiel developers was also identified as a significant problem.

Recommendations

The findings led to the development of several recommendations to correct program weaknesses within AMC and to institutionalize sound engineering for transportability practices throughout the design and development process. Recommendations for improvement fell within three broad categories:

- administrative and regulatory changes to emphasize and clarify transportability engineering within the materiel design process,
- organizational alignment to include information and training programs to increase awareness of transportability considerations, and
- operational actions to improve transportability engineering.

A coordinated and timely effort among AMC, TRADOC, MTMC, and HQ DA has resulted in the majority of the recommendations from each of the above categories being fully implemented with other planned actions.

Engineering for Transportability—the Key

To borrow a slogan often used by the MTMCTEA, "Excellence in strategic mobility begins with good transportability engineering." As part of their mission, MTMCTEA administers the DA portion of the Engineering for Transportability Program and has as one of its functions to prepare and publish DOD materiel-transportability guidance and provide related evaluations, advice, studies, reports, and documentation. The engineering for transportability process is key to ensuring materiel meets its transportability requirements.

Without properly applied transportability engineering, strategic mobility would be weakened. Materiel and units that are not easily transportable cannot be readily deployed and are of little value to the Army when a mission requires quick response. Fully transportable materiel and units must be achieved to ensure full strategic mobility when rapid deployment is essential. The key is deliberate and well planned transportability engineering.

Design Influence

Although transportability is an integrated logistic support element, it is also a systems engineering design element. Engineering for transportability is the proactive responsibility of the materiel developer community to design materiel capable of being easily and safely transported on required existing and planned transportation assets. Both tactical and strategic transportability considerations must be designed into the system. This influence is greatest at the beginning of the acquisition cycle when the design is not locked-in and the costs are minimal for design changes. The item engineer should ensure that all the transportability requirements have been incorporated into the design as early as possible in the acquisition cycle.

The transportability of all associated support items integral to the system being developed should also be planned for as early as possible. It must be emphasized at this point that early coordination with the MTMCTEA transportability engineers is the best way to ensure that an item will meet its transportability requirements.

Key Initiatives

During the past few months the process of ensuring that transportability considerations influence the item design has received considerable attention. Numerous initiatives are underway to institutionalize engineering for transportability and several others are planned for the future. Examples of some of the more significant actions currently underway to institutionalize the Engineering for Transportability Program and to discipline the process include:

- Transportability constraints are being addressed up front, as early as the Operational and Organizational Plan, with follow-on requirements documentation further clarifying the requirements.

- All requirements documentation is being staffed with the MTMCTEA transportability engineers and MTMC is participating in the TRADOC Requirement Review Committee meetings.

- Program/project/product managers are now addressing transportability as an element of the acquisition strategy.

- MTMCTEA performs a system transportability engineering analysis prior to each milestone review to identify any issues impacting transportability approval.

- Transportability is now an agenda item at TRADOC Materiel Evaluation Committee reviews and AMC senior level review boards such as the Materiel Acquisition Review Board and the Materiel Acquisition Decision Process when there are transportability issues.

- The commander, MTMC, who is the Army transportability agent, will be designated an official member of the In-process Review and Army System Acquisition Review Council when transportability issues are not resolved.

- MTMC transportability approval is now required to proceed through any of the acquisition cycle milestones for both nondevelopment items and research and development acquisitions.

These examples demonstrate the importance transportability considerations now have in the materiel acquisition process. However, the greatest challenge still remaining is educating the field. Initiatives in this area and those to increase awareness of the Engineering for Transportability Program include the recently published MTMC Pamphlet 70-1, Transportability for Better Strategic Mobility. This pamphlet is an excellent guide for anyone interested in transportability, including decision makers, materiel and combat developers, design engineers, users, logisticians and transporters. It was not designed to make someone an instant transportability expert, but it will help those concerned to better understand the Engineering for Transportability Program and the various transport modes.

Additionally, the MTMCTEA is planning to present executive and working level seminars on transportability and the Engineering for Transportability Program at each of the AMC commodity commands. These seminars will be a major step in improving the understanding and execution of the transportability process in materiel acquisitions. Other initiatives include incorporating transportability instruction into the Program Management Course at the Defense Systems Management College and transportability articles periodically appearing in this, as well as other, DOD publications.

Downsizing Equipment

We have seen the need to emphasize transportability as a key element of the acquisition process and this emphasis is becoming constantly more evident as modernization of our systems leads to a heavier force. Our equipment modernization programs provide us an impressive combat capability, but new systems are often larger, heavier, and consequently less deployable than those systems being replaced. According to recent analysis performed by MTMCTEA, even since April 1983, weight has significantly increased in each of the five TRADOC type Table of Organization and Equipment divisions. This increase in weight translates into greater demands placed on already limited transportation assets.

Our challenge now is to balance equipment growth with transportability and deployability requirements. Equipment size and weight growth must stop. The heavy-up trend must be reversed by "lightening the force" and Chief of Staff

USNS Jupiter Loading

Unit equipment has been prepared for loading onto the "roll on/roll off" capable USNS Jupiter during a REFORGER exercise.

of the Army GEN John A. Wickham has challenged the Army to do just that.

Lightening the force is a program to enhance the deployability of the force which includes actions to strengthen the light forces, Special Operation Forces, and light divisions; to significantly lighten systems used by the entire force; and to significantly reduce the support tail (manpower and materiel) of the entire force. As part of the overall Army objective to lighten the force, AMC and TRADOC have been investigating and developing initiatives to "downsize" equipment by reducing the weight and/or size of Army systems.

Concept

A key element of an effective program to structure a coordinated effort to downsize Army systems/components is early identification and planning for the requirement. It is essential that downsizing requirements are clearly stated in requirements documentation and written to allow development and retrofit of componenets/subsystems reduced in weight and/or size to specific objectives, (e.g., initial weight of 40 tons must be reduced to 35 tons not later than 4th quarter, FY95). In this instance, the preplanned product improvement approach would be appropriate in order to meet the future requirement.

Using preplanned product improvement, the basic system is developed along with the required design considerations to accommodate the insertion of a lighter/smaller component or subsystem to meet the requirement. For example, the procurement strategy could be a design for an initial suspension system using steel, with a parallel effort using lighter weight composite materials to replace the much heavier steel system. This allows early fielding of the basic system with its attendant advantages and enables future improvements to achieve the weight reduction at a much less cost than traditional methods.

The downsizing effort is not just limited to those systems under development. Efforts have been underway by AMC and TRADOC to identify all candidate systems for potential downsizing to include production and fielded systems. As each system is identified, it will be considered for downsizing with modifications planned according to the priority of effort assigned to the system in accordance with the Mission Area Materiel Plan. Downsizing initiatives range from near-to-far-term efforts with detailed plans tied to schedules and resource constraints. Downsizing efforts have been initiated on several systems and examples include efforts across all commodity areas from downsizing the load carried by the individual soldier to development of a downsized armament package to reduce the weight of our current tank.

Summary

As the Engineering for Transportability Program gains momentum at all levels within the Army RD&A community, we should be seeing equipment coming off the production lines that is fully transportable by all required transportation modes. The key is designing transportability into the item from the very beginning and ensuring early and continuous coordination with the MTMCTEA transportability engineers throughout the acquisition process.

While the downsizing program moves forward, we should begin to see a reverse in the heavy-up trend our materiel has taken in the past. Along with properly applied transportability engineering, downsizing our equipment will lead us to a lighter and more mobile force capable of deployment to any conflict area, when needed.

CPT(P) BARRY M. WARD is a research and development coordinator assigned to the Systems Integration Division, Office of the Deputy Chief of Staff for Development, Engineering and Acquisition, HQ, AMC. He has a B.S. degree in engineering from the U.S. Military Academy and is a graduate of the Program Management Course, Defense Systems Management College.

ATTENTION AUTHORS

Do you have an article you would like to submit for possible publication in the *Army RD&A Magazine?* If so, we would like to hear from you. Consideration will be given to all articles, based on importance of the subject, factual content, timeliness, and relevance to the magazine's mission. The following are general guidelines for submissions:

- ***Length.*** Articles should be about 2,000 words. Shorter or longer articles are acceptable, depending on what is required to adequately tell the story.
- ***Photos.*** Include any photographs or illustrations which complement the article. Black and white or color are acceptable. We cannot promise to use all photos or illustrations and they are normally not returned unless requested.
- ***Biographical Sketch.*** Include a short biographical sketch and a photo of the author(s).
- ***Clearance.*** Articles must be cleared by author's security/OPSEC Office prior to submission.

Articles may be submitted by regular mail or by "electronic mail." OPSEC clearances and photographs must still be sent by regular mail if articles are submitted electronically. Mailing addresses are:

Regular Mail. HQ, AMC, Army RD&A Magazine (ATTN: AMCDE-XM), 5001 Eisenhower Avenue, Alexandria, VA 22333-0001.

Electronic Mail: amcde-xm @ amc-nq.

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Treatment of VOC Contaminated Soils

By Donna L. Koltuniak

The U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), in the Edgewood Area of Aberdeen Proving Ground, MD, has dual Army responsibility for installation restoration and demilitarization of unserviceable or obsolete chemical agent munitions. It also serves as the lead agency within the U.S. Army Materiel Command (AMC) for pollution abatement and environmental control technology development. In this role, USATHAMA conducts generic R&D studies with wide application to current U.S. Army environmental problems. Two such R&D studies for treatment of soils contaminated with volatile organic compounds (VOCs) are addressed in this article.

Background

Contamination of soils from past solvent-handling practices has become one of the predominant environmental concerns at several U.S. Army installations. Trichloroethylene (TCE) is the most frequently occurring contaminant; however, quantities of other VOCs such as dichloroethylene and tetrachloroethylene have also been found. If allowed to remain in the soil, these compounds can contaminate underlying groundwaters utilized as drinking water. Potential for migration of contaminated groundwaters beyond Army property boundaries further heightens the concern.

How does one address the problem of VOC contaminated soils? To date, accepted remediation technology has consisted of containment, or excavation and disposal, or a combination of the two. Containment, enclosing the contaminated area with an impervious clay or synthetic barrier, can alleviate the migration potential of the VOCs by significantly decreasing the amount of precipitation and groundwater percolating through the site, thus limiting the spread of contamination. However, this approach does not totally eliminate environmental concern associated with the site. The actual contamination still remains, therefore, the site must be continually maintained and monitored to insure the effectiveness of the containment measure.

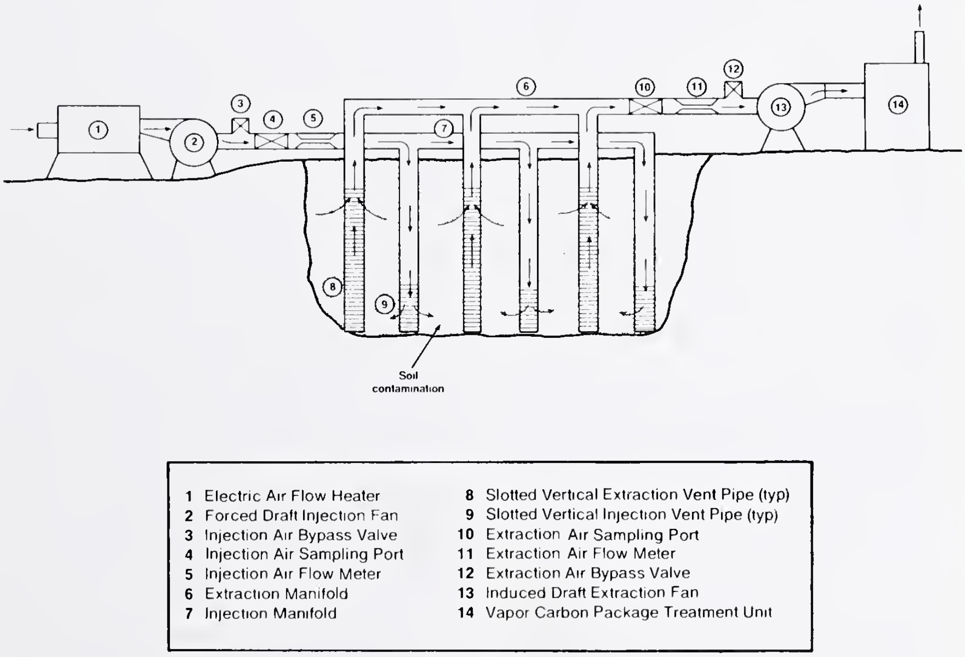
Excavation and disposal of the VOC contaminated soil in a secure hazardous waste landfill, contrary to containment, offers the advantage of actual contaminant source removal. However, although site-specific concern is eliminated, the associated environmental concern is merely transferred to the hazardous waste landfill facility. Liability remains with the waste producer who, in the event of facility failure, could be required to make compensation to the affected parties. Add to this scenario the fact that TCE has been known to breach clays and synthetic materials typically used as liners in landfill systems and the option becomes even less appealing. Furthermore, landfilling is expensive; given the wide-spread area over which VOC contamination normally occurs, thousands of cubic yards of soil may need to be excavated and landfilled at upwards of $100 per cubic yard.

Therefore, remedial actions represent stop-gap measures, at best. To totally remove the threat to human health and the environment posed by VOC contaminated soils, the soils need to be treated to remove the VOCs to acceptable levels.

USATHAMA is currently developing two separate technologies for treatment of VOC contaminated soils. The first technology, called "in situ air stripping," treats soils in-place. The second technology, "thermal stripping," requires excavation of the soils for subsequent treatment. Both technologies have been successfully field demonstrated.

In Situ Air Stripping

The in situ air stripping process is based upon technologies that have been applied by others to remove volatile petroleum products from subsurface soils. The fundamental concept is quite simple: clean air is mechanically injected into the contaminated in-place soils and forced to travel through the soils, vol-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Soil contamination
1 Electric Air Flow Heater
2 Forced Draft Injection Fan
3 Injection Air Bypass Valve
4 Injection Air Sampling Port
5 Injection Air Flow Meter
6 Extraction Manifold
7 Injection Manifold
8 Slotted Vertical Extraction Vent Pipe (typ)
9 Slotted Vertical Injection Vent Pipe (typ)
10 Extraction Air Sampling Port
11 Extraction Air Flow Meter
12 Extraction Air Bypass Valve
13 Induced Draft Extraction Fan
14 Vapor Carbon Package Treatment Unit

Figure 1. In situ air stripping pilot study apparatus.

atilizing the trapped VOCs. The contaminated air is then withdrawn from the soils and either vented to an emission control system or the atmosphere, depending on VOC concentrations.

The in situ air stripping system, shown in Figure 1, consists of a series of interconnected air injection vents fed by an above-ground blower and manifold system. A separate blower and manifold system is used to apply negative (vacuum) pressure to air extraction vents, which are also interconnected. All vents are installed to the lowest depth of the contaminated zone yet above the groundwater table. Both series of vents are perforated and grouted along predetermined lengths to prevent major short-circuiting of air flow to the ground surface. To achieve a form of flow containment, extraction vents are placed on the outer perimeter of the area to be treated, surrounding an innermost array of injection vents.

In Situ Field Tests

A study of the in situ air stripping process was conducted by USATHAMA at an actual VOC-contaminated site from Nov. 19, 1984 to Feb. 22, 1985. The primary purpose was to perform a pilot-scale field demonstration of the process to determine system effectiveness for removal of VOCs from in-place soils.

Secondary study objectives sought to evaluate design parameters such as injection/extraction vent spacing, air flow rates, system air pressure, moisture content, and temperature, for full-scale application of the technology. Therefore, two distinct pilot systems were installed at the test site.

System 1, designed to evaluate the effectiveness of the in situ air stripping process for soils with low initial VOC concentrations (less than 2.3 parts per million (ppm)), covered an area 50 feet by 50 feet in size, with injection/extraction vents installed on 20-foot interval spacings. Air flow rate for System 1 was maintained at 50 cubic feet per minute (cfm).

System 2 spanned an area 100 feet by 100 feet in size adjacent to System 1, and was designed to test technology effectiveness for soils with high initial VOC concentrations (up to 5,000 ppm). Vents were placed at 50-foot intervals and air flows were varied from 50 cfm to 300 cfm. For both systems, injection and extraction vents were placed to the depths of the VOC contamination, 20 feet. Given the possibility of high VOC concentrations in the process effluent air stream, effluent air from both systems was treated by a vapor-phase carbon adsorption system prior to release to the atmosphere.

The sampling and analysis program for the pilot study focused on TCE. Although other VOCs were known to be present at the test site, TCE was identified as the primary contaminant, thus it was designated the "indicator" compound and used to evaluate technology effectiveness. Measurement and monitoring of TCE concentrations in the effluent air stream were instrumental in determining whether or not TCE was actually being removed from the soils, and were correlated with results of soil sampling and analysis conducted before and after system operation.

In Situ Test Results

System 1 effluent air TCE concentrations began in the 30-70 ppm range and by the end of 10 weeks of system operation were below 500 parts per billion. A mass balance based on initial estimates of TCE present at the System 1 site and effluent air concentrations indicated that approximately 75 percent of the TCE was removed during the pilot test period. Final soil sampling and analyses results substantiated the calculated removal rates, indicating up to 99 percent decreases in the TCE concentrations.

System 2 effluent air TCE concentrations began quite high (in the 250-300 ppm range) and remained thus throughout a 14-week test period. The decrease of TCE concentrations in the effluent air, felt to be indicative of substantial technology effectiveness, was not exhibited during the test period. However, this phenomenon was not totally unexpected. As stated earlier, System 2 was installed in an area of significantly greater TCE concentration than System 1; therefore, since the system had to remove a greater volume of TCE, more operation time would be necessary for System 2 to effect significant TCE removal characterized by the substantial decrease in effluent air TCE levels. Nevertheless, effluent air TCE concentrations showed that greater than 1,600 pounds of TCE had been removed from the study area in the 14-week test period, at an average rate of 20 pounds per day.

A mass balance based on initial estimates of TCE present at the System 2 site and effluent air TCE concentrations indicated that approximately 25 percent of the TCE was removed during the pilot test period.

The pilot study conducted at the contaminated site showed that the in situ air stripping process is effective for removal of VOCs from in-place soils. The process is considerably more attractive because in-place treatment negates the need for soil excavation and handling, factors which contribute significantly to typical treatment/disposal costs. Major insights were also gained regarding design and operation criteria for the technology.

Although the in situ air stripping process has been proven effective for removal of VOCs from soils, there are limitations to the application of the technology. As one can easily surmise, loose, sandy soils well above the groundwater table are most amenable to in situ air stripping. This is due to the fact that the process air can flow relatively unrestricted through the soil system, providing good soil/air interface, and thus, good volatilization of the VOCs. In contrast, many sites exhibit conditions likely to restrict air flow in the soil system, i.e. tightly-packed soils, soils with high clay content, rock formations, debris, and high groundwater table. For sites such as these, where in situ air stripping is not plausible, an alternative technology called "thermal stripping" is being developed by USATHAMA.

Thermal Stripping

The thermal stripping process requires that the contaminated soils be excavated from the site for subsequent processing. Once excavated, the soils are placed in an indirect heat exchanger, called a thermal processor, where they are heated to the temperatures necessary to volatilize the VOCs from the soil matrix. Upon volatilization, the VOCs are directed to an afterburner for destruction. The soils, now relatively free of VOCs, exit the processor for disposal.

The heart of the thermal stripping system, the thermal processor, is used in industry as a dryer for powdered solids and viscous liquids; use for treatment of VOC contaminated soils represents a new application of the equipment. The thermal processor unit consists of a parallel double screw mechanism housed in a jacketed trough. The screw shafts and flights, as well as the trough, are hollow to accommodate circulation of heating fluid (i.e. hot oil). The temperature of the heating oil is controlled from ambient to a maximum of 315 C (600 F) by an electrical resistance heater.

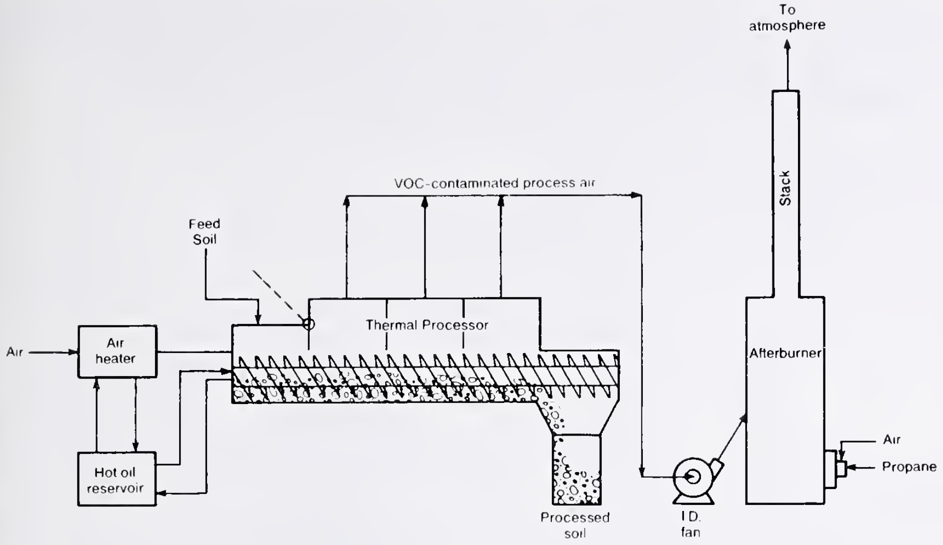


Figure 2. Thermal stripping pilot study apparatus.

The oil is recirculated through the system continuously throughout treatment operations, never contacting the soil, but rather heating the processor screws and walls which, in turn, heat the soil. The turning action of the screws and the intermeshing of the screw flights act to thoroughly mix the soil, providing good soil/air/heat interface, and thus improving contaminant volatilization. Residence time of the soils in the processor can be varied by adjustment of the rotation speed of the screws, as desired, or by increasing the length of the unit used.

Air is introduced to the thermal processor unit to enhance VOC removal and collect the volatilized compounds. The temperature of the air is controlled by an air preheater from ambient to 70 C (158 F). Once it exits the thermal processor, the air containing the stripped VOCs is combusted in an afterburner for complete destruction of the compounds. The afterburner provides a residence time of greater than two seconds at a temperature of 1,000 C (1,832 F). Depending on the air pollution regulations at the particular site where the process is employed, other methods of air pollution control, (e.g. carbon adsorption, molecular sieve, etc.), may be required or more desirable. The thermal stripping system is shown in Figure 2.

Thermal Stripping Field Tests

A study of the thermal stripping process was conducted by USATHAMA at an actual VOC contaminated site from Aug. 5, 1985 to Sept. 16, 1985. The primary purpose of the study was to perform a pilot-scale field demonstration of the process to determine system effectiveness for removal of VOCs from soil.

Secondary objectives addressed optimization of system performance for full-scale application of the technology. Although one thermal processing unit was used during the testing, operating parameters such as soil residence time, soil discharge temperature, soil feed rate, and process air temperature were varied to ascertain the effect on soil treatment effectiveness and efficiency of the thermal stripping process.

During 32 days of formal testing, approximately 15,000 pounds of VOC contaminated soils were processed. A detailed sampling and analysis program was conducted for each test run. Composite soil samples were collected at the soil excavation site, prior to feed into the thermal processor, and after discharge from the unit. Air VOC concentrations and corresponding removal efficiencies were determined from the ambient air entering the processor, the off-gas leaving the processor, and the stack gas downstream of the afterburner. In addition, particulate and hydrochloric acid emissions were sampled in the afterburner stack to determine need for air pollution control devices.

A portable field gas chromatograph (GC) was used to provide continuous real time total VOC emission monitoring in each of the three air discharge lines from the thermal processor during actual testing. A mobile gas chromatograph/mass spectrometer (GC/MS) was also used at the site during one week of testing to provide additional qualitative and quantitative VOC data at the same locations. All soil and air samples collected as described above were analyzed using a GC/MS at a USATHAMA-certified laboratory. These analyses provided complete and accurate identification of all VOCs present in the samples.

Thermal Stripping Test Results

The pilot study of the thermal stripping process demonstrated that the process is highly effective for treatment of VOC-contaminated soils. Thirty-two days of formal testing were conducted with no downtime lost to equipment failure or malfunction. Over 15,000 pounds of soil were processed during the testing period. Concentrations of VOCs in the soils were extremely high, often as high as 22,000 ppm. As can be seen from the accompanying table, significant removal and destruction of VOCs was achieved.

A comparison of the VOCs measured in the feed soil to VOCs measured in the processed soil and stack gas yielded the following destruction and removal efficiencies:

- Greater than 99.99 percent removal of VOCs was evidenced in the soils.
- No VOCs were detected in the stack gas, indicating an efficiency for the overall system of 100 percent.
- Afterburner stack emissions were in compliance with all federal and state regulations (including VOCs, hydrochloric acid, CO, and particulates).

As with the in situ air stripping pilot study, major insights into the equipment design and operating parameters were also gained.

Follow-Up Actions

The success of the pilot studies/field demonstrations of the two technologies has resulted in significant follow-on development efforts to be pursued by USATHAMA. The significant findings of the in situ air stripping pilot test have resulted in full-scale applications of the technology at two VOC-contaminated sites located on a U.S. Army installation in Minnesota.

The full-scale use of the process has received approval from state and federal regulatory authorities as a remedial "demonstration" effort as opposed to a remedial action effort. This is due to the fact that the ultimate effectiveness of the

Summary of Soil VOC Concentrations and Maximum VOC Removal Efficiencies

VOC	Feed Soil Concentrations Average (ppm)	Feed Soil Concentrations Maximum (ppm)	Maximum Removal Efficiency
Dichloroethylene	83	470	100%
Trichloroethylene	1,673	19,000	100%
Tetrachloroethylene	429	2,500	100%
Xylene*	64	380	100%
Other VOCs	14	88	100%
Total VOCs	2,263	22,438	>99.99%

**** Xylene is not classified as a VOC since its boiling point is approximately 140 C. However, it was included in this study to evaluate the effectiveness of this technology on high boiling point semi-volatile compounds.***

in situ air stripping process is, as yet, unknown, (i.e., final clean-up VOC concentrations achievable with the process have not yet been determined). Therefore, USATHAMA's continuing development of the process will center on evaluation of the remedial demonstration usage, as well as additional laboratory/bench scale studies relevant to the process.

Based upon the unqualified success of the field demonstration of the thermal stripping process, USATHAMA is proceeding with the following phases of technology development:

- development of optimized design and performance criteria for full scale implementation of the thermal stripping process,
- development of life cycle costs for comparison of the thermal stripping process to alternative treatment/disposal options applicable to VOC-contaminated soils, (such as in situ air stripping), and
- preparation of detailed thermal processing equipment bid specifications for full-scale applications of the technology.

DONNA L. KOLTUNIAK is a project engineer with the Environmental R&D Team, Technology Division, U.S. Army Toxic and Hazardous Materials Agency. She earned a B.S. degree in civil engineering from Florida Technological University in 1980. Prior to joining the Army Toxic and Hazardous Materials Agency, she was a design engineer in private industry.

Counterobstacle Vehicle Demonstration

Multi-purpose capabilities of the counterobstacle vehicle (COV) were displayed late last year during a demonstration at the U.S. Army Belvoir Research, Development and Engineering Center (BRDEC) Engineer Proving Ground. Under development as a potential replacement for the M728 combat engineer vehicle, the COV was put through its paces in both its bulldozer and mine plow modes. Two separate vehicles were used for the demonstration.

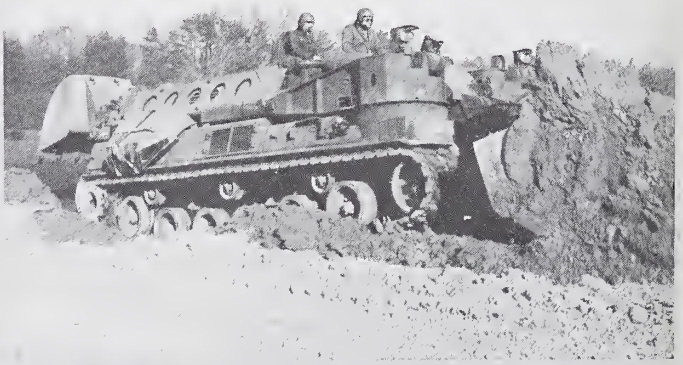
The COV in the bulldozer mode traversed several ditches and cleared and climbed an 85 percent bank through heavy foilage. The other COV, with its mine plow attachment, cleared several long paths in simulating its mine clearing capabilities

The COV offers significantly improved mobility, countermobility and survivability in performing rapid breaching of minefields, obstacle and rubble removal, and obstacle construction.

LTC Bill Ryan, BRDEC project officer for the COV, explained to the demonstration attendees that today's smart mine fuzes are much more difficult to defeat than the older pressure-type mines, but that the COV can effectively attack and clear the new mines.

A key feature of the counterobstacle vehicle is that it is being developed by integrating several proven technologies, including modification of a standard M88A1 armored recovery vehicle, an M88A1 transmission, an Israeli developed mine plow/dozer blade, commercially adapted telescopic arms, and a 908 horsepower turbocharged, air-cooled diesel engine.

Operated with a crew of three (one less than the current M728), the counterobstacle vehicle is being developed under an acquisition strategy that calls for its type classification and initial production in FY90.



Bulldozer blade moving earth to fill anti-tank ditch.

ARO Technical Note

Squeeze Film Damper Bearings

By Dr. John A. Tichy

Background

In recent years there has been a trend to increase power-to-weight ratios in military machinery, especially in aviation. Such conditions are obtained by reducing the weight, and consequently the stiffness, of rotors and structures, and by increasing rotational speeds. As a result, modern machines are very susceptible to a variety of problems in their dynamic behavior, such as excessive vibration, instability, rotor whirl, etc. Due to these problems, the engineering discipline of rotor dynamics has arisen.

Before any large or complex high speed rotating machine is built (e.g., turbines, compressors, and aircraft engines), a computer model of the entire machine is constructed with idealized elements for various components such as shafts, seals, massive rotors and, most importantly, bearings. The designer seeks to avoid problems in the machine by finding, through the computer model, which combinations of speeds, shaft geometries and bearing parameters cause the undesirable behavior.

Bearings are devices to position one machine part with respect to another so that relative surface motion is possible. There are two main types. The first type is fluid film bearings such as the journal or sleeve bearing, where the surfaces are separated by a lubricating fluid. The second type is rolling element bearings such as ball bearings and roller bearings where the relative surface motion is permitted due to the rolling of an intermediate ball or cylinder. Each of these two basic types has attendant advantages and disadvantages based on mechanical requirements (load, speed, friction, etc.), environmental conditions (temperature, presence of corrosives, etc.), and economics (cost, life, maintenance, etc.).

Many factors seem to favor rolling element bearings in high speed military machinery. Bearings must perform well at a wide temperature range, the required life is relatively low, and limited operation may continue after failure. By contrast, in fluid film bearings, if lubricant supply is lost, failure is sudden and catastrophic, which is clearly unacceptable in aviation applications. There is a major disadvantage of rolling element bearings, however, because they have almost no damping, or means of absorbing the energy of vibrations. This means that rolling element bearings tend to increase susceptibility to rotor dynamics problems.

Squeeze Film Damper Bearings

Enter the squeeze film damper bearing, a device which takes advantage of the best features of rolling element and fluid film bearings. The squeeze film damper is essentially a rolling element bearing within a fluid film bearing (Figure 1). The inner race of the rolling element bearing rotates with the shaft. The outer race is fastened to some sort of flexible support, such as the "squirrel cage" shown, which also prevents rotation of the outer race. The squirrel cage goes all around the bearing (not shown), and the other end fastens to the main body of the engine. The outer race assembly forms the inner cylinder of the fluid film bearing and a stationary housing comprises the outer cylinder. A thin fluid film is trapped between the two cylinders which is squeezed as the shaft vibrates. The scale of the figure is misleading. If the cylinder diameter is 6 inches, the film is only about 0.005-inches thick.

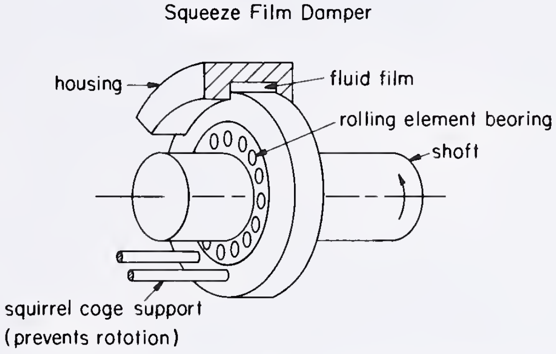


Figure 1. Schematic of the squeeze film damper bearing.

Keep in mind that Figure 1 is a schematic—there are many details and individual designs with seals, lubricant feed holes and supply grooves, etc. In addition, a mean pressure level above atmospheric may be imposed through an external pump of some type.

Hydrodynamic Lubrication Theory

The flow of lubricant in thin film is rather complex but some of the basic ideas involved have been known for a century. In 1886, Lord Osborne Reynolds developed the theory of hydrodynamic lubrication which has by and large well served the mechanical engineer to this day.

The Reynolds theory assumes that the fluid is very viscous and that the surface motion is sufficiently slow, that is, the "Reynolds number" is very small. Under these conditions the damper film works as follows. At some instant of time, the shaft assembly may move in a particular radial direction due to vibration, thus squeezing the fluid. The fluid flows along the circumference away from the squeezing direction. A large pressure builds up in this region due to viscous forces in the fluid opposing the squeezing motion. At the diametrically opposite region, precisely the reverse occurs—fluid flows to this region and negative pressure (relative to the imposed pressure) results. If this negative pressure falls sufficiently low, the lubricating fluid may cavitate (turn to vapor). The pressure generated in this way resists further motion of the shaft and serves to suppress or dampen the vibrations. By this process, the kinetic energy of the vibrating shaft is dissipated in the fluid.

Real World Application

Unfortunately, in the real world, dampers do not quite work like the theory says. This causes two kinds of problems. First, the squeeze film damper bearings may not work properly.

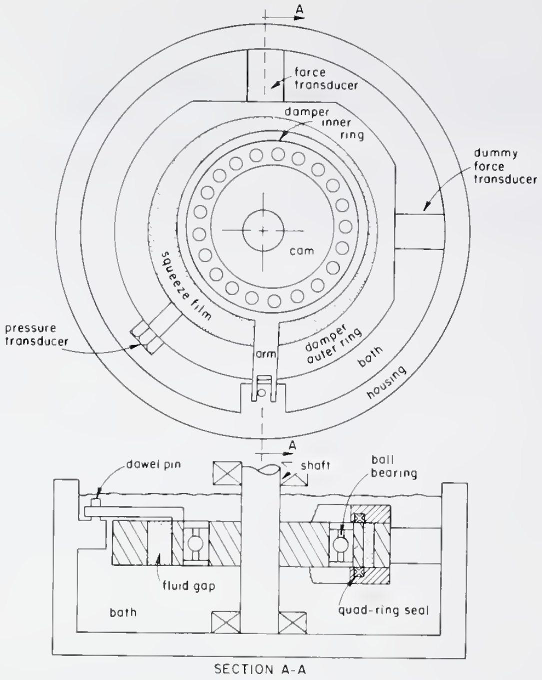


Figure 2. Schematic of RPI experimental squeeze film damper apparatus.

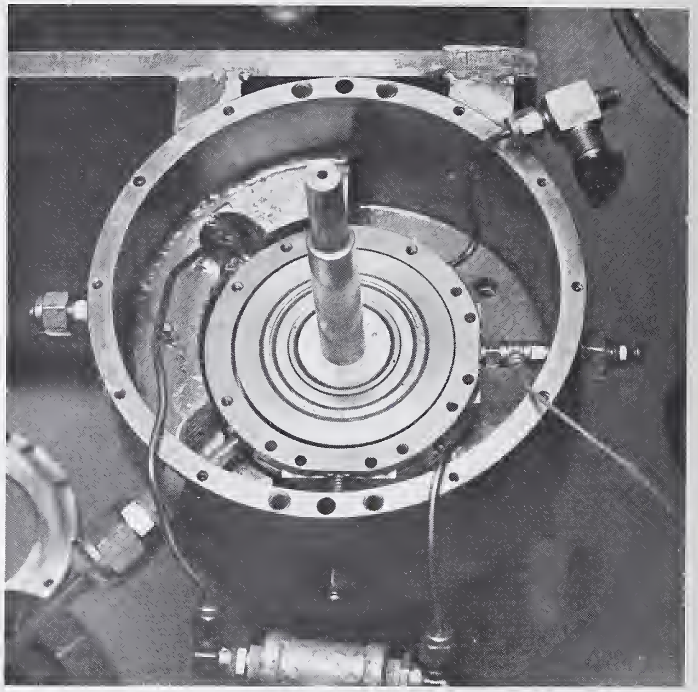


Figure 3. Photograph of partially disassembled experimental apparatus.

Second, the rotor dynamic computer models discussed above have traditionally relied on the Reynolds theory to describe the damper bearings. If the bearings do not really behave like the theory says, the entire machine may be poorly designed with unforeseen vibration problems at certain so-called critical speeds in the normal range of operation.

As a rule, the critical speeds cannot be eliminated, but through careful "tuning" of many machine component parameters, their severity can be reduced or they can be pushed out of the operating speed range. Fixing a machine rotor dynamic problem once it has been built is an extremely difficult task, but unfortunately many problems are attacked in just this way.

The difficulty with the Reynolds theory is due to the small Reynolds number assumption. The small Reynolds number implies that fluid inertia forces (forces required to accelerate the fluid) are negligible relative to viscous forces. However, the damper fluid is not very viscous. This fluid is also used as the rolling element bearing coolant. It is present in the damper at quite high temperatures (approximately 300 F) and its viscosity at these temperatures is not much greater than that of water. Also, the surface speeds are not necessarily "sufficiently slow" in such high speed machines.

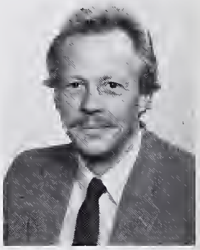
Under the conditions of low viscosity and high speed, the pressure due to inertia (ignored by the Reynolds theory) may be greater than that due to viscosity, and may occur at different instants of time and different circumferential locations around the bearing, relative to predictions of the theory.

The U.S. Army Research Office has sponsored a project at Rensselaer Polytechnic Institute (RPI) in Troy, NY, to study this sort of anomalous behavior in squeeze film damper bearings. An improved theory has been developed which includes inertia and viscous effects. This work has revealed that a much larger pressure exists than was previously predicted, and the maximum pressure is located circumferentially up to 90 degrees ahead of the squeezing direction. This effect is sometimes called "cross-coupling," meaning that motion in a given direction causes a force in the cross-direction. These forces can potentially be a destabilizing factor which promote whirling of the shaft about a central axis. Therefore, more careful and sophisticated rotor dynamic analysis is called for to assure smooth running machinery. This fact has been noted by workers in the field, in which the actual machine behavior has not always conformed to the rotor dynamic predictions.

An experimental squeeze film damper apparatus has also been developed at RPI, see Figures 2 and 3. A known vibration is imposed by the eccentric cam. Pressure within the fluid and the total force on the damper are measured and checked against predictions of the improved theory. The improved theory does a much better job than the classical Reynolds theory but there are still a number of outstanding problems to be resolved.

Fortunately, the improved theory can be expressed in the form of a relatively simple modification to the classical Reynolds theory and is fairly easy to incorporate in existing rotor dynamics programs. This has been done already in several industrial and military aviation applications. Researchers are quite certain that smoother running machinery will result, with many fewer costly and time consuming "cut and try" solutions on the built machine being required. Design and application of squeeze film dampers is slowly being raised from its previous "black art" status.

DR. JOHN A. TICHY is associate professor of mechanical engineering at Rensselaer Polytechnic Institute. He obtained his Ph.D. degree from the University of Michigan in 1970 and has been at RPI since 1976. He is principal investigator on a U.S. Army Research Office sponsored project involving squeeze film dampers.



From The Field. . .

Icing Severity Level Indication System

A 12-month, $291,439 contract for the flight test evaluation of an Advanced Icing Severity Indication System (AISLIS) has been awarded by the U.S. Army Aviation Systems Command's Aviation Applied Technology Directorate (AATD), Fort Eustis, VA, to Canadian Commercial Corp. which will subcontract with Leigh Instruments, Ltd. The AISLIS wil be installed on a UH-1H helicopter and initially tested in clear air at Edwards Air Force Base, CA, and later under icing conditions in Duluth, MN.

"The objective of this program is to demonstrate that the AISLIS can accurately display the severity of the icing condition which the aircraft is flying in," explained Harvey R. Young, AATD project engineer. "This will allow more of the helicopters to be used that are now restricted due to marginal weather conditions."

New X-ray Unit at MTL

The U.S. Army Materials Technology Laboratory's (MTL) Nondestructive Evaluation (NDE) Branch (Mechanics and Structural Integrity Laboratory) is seeing more than ever.

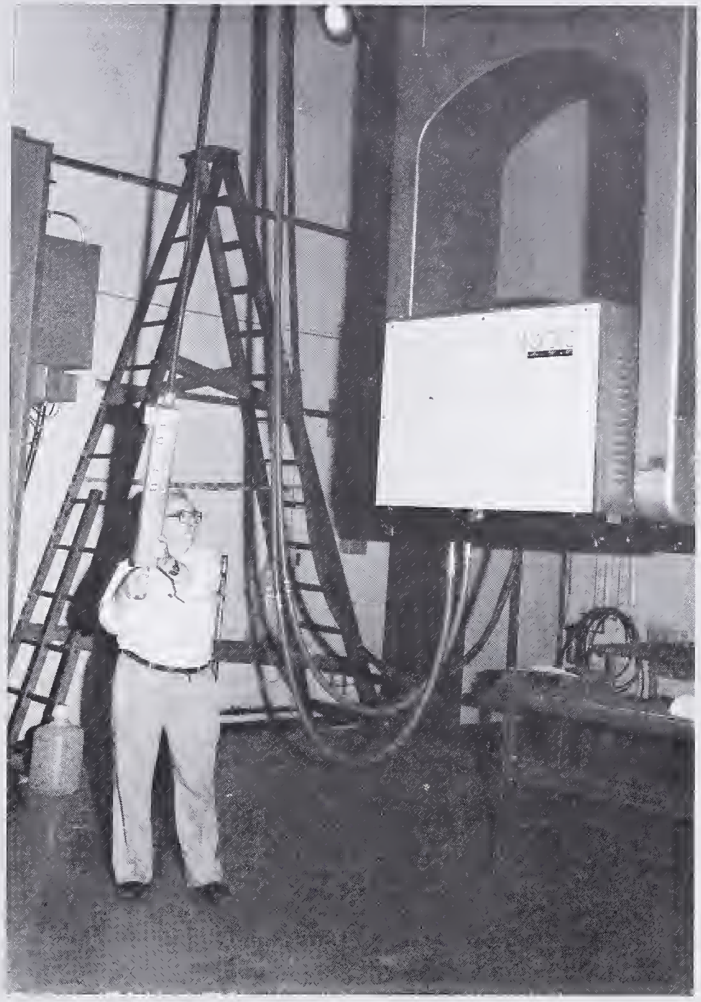
MTL's new source of pride is a high energy X-ray machine. The Varian Linatron is showing materials' characteristics and shortcomings and allowing the lab to perform better quality control and assurance. Its enhanced X-ray capability is being used mainly in the non-destructive testing of materials specimens, armor plate, bridging, armaments and vehicle components.

"This new equipment will significantly benefit and support MTL's materials analysis capability," says Alfred L. Broz, chief of the NDE Branch, "especially in our armor and penetrator programs.

"With the Linatron, we will be looking for cracks and porosity and changes in material density. This X-ray process is complementary to our NDE in ultra-sonics where we can see cracks and material modifications. Using the Linatron, we can see the difference in the X-ray beam as it goes through the material; ultrasonics also measure sound waves perpendicular to the beam. Now, we have another tool in our NDE arsenal for determining the condition of materials."

The Varian Linatron is one of the most modern X-ray machines available, according to Broz, and produces excellent film resolution. In fact, the Linatron is also used in hospitals as an X-ray source. The Linatron is ideal for seeing into material 1-inch to 8-inches thick.

As for the safety of the Linatron, Broz says that its installation has been approved by the U.S. Army Environmental Hygiene Agency and is very safe. The actual X-ray exposures are made by the technician using remote computer control from behind a 4-foot wall. It also has an automatic exposure meter which can be utilized to produce uniformly and consistently exposed radiographs (X-rays). "The automatic exposure meter eliminates the trial and error technique which is generally used for determining exposures for new applications," says Broz.



Bernard Monagle, U.S. Army Materials Technology Laboratory, Nondestructive Evaluation Branch physical science technician, uses the Varian Linatron's remote control unit to set the machine up for nondestructive testing.

The unit has been up and running since last June. "This type of X-ray inspection helps ensure quality assurance and quality control for materials in manufacturing processing. The materials that we are now inspecting and testing will, in the future, be of the highest quality as they are incorporated into the defense systems used by American soldiers in the field," says Broz.

Automated Camouflage Design

The Army Troop Support Command's Belvoir RDE Center, Fort Belvoir, VA, has awarded the first increment of a multi-year contract to establish the Army's first automated camouflage pattern generation facility.

The one million dollar award to Mandex Inc., Vienna, VA, covers the procurement and installation of computer-aided design equipment in a contractor facility, training operators to design camouflage patterns, and initiating production.

The new facility will be used to design the three-color camouflage pattern now replacing the standard four-color on all Army tactical and mobility ground equipment. Its computer-generated patterns are expected to be more precise in the ratio of black, green and brown shapes, and cost less than the current hand design. Estimates are that computerization will cut five weeks of painstaking manual drawing to less than a week of automated design.

The computer system will employ CAMOGEN, a special software program developed for the center by BDM Corp., to present a 3-D view of a piece of equipment from the manufacturer's blueprint. Seeds of color automatically planted on the image, following stored camouflage pattern criteria, will then grow in proper ratio to camouflage the entire item. After regions of color are set, the computer draws boundaries around each to mark the color location. The pattern is then printed at any desired angle.

ETL Demonstrates Terrain Analyst Work Station

Late last year Army terrain analysts had a chance to try out the type of automated equipment they'll be using in the future. Scientists from the U.S. Army Engineer Topographic Laboratories (ETL) demonstrated the Terrain Analyst Work Station (TAWS) at 1st Armored Division Headquarters in Ansbach, West Germany. TAWS is part of the Corps of Engineers' AirLand Battlefield Environment thrust.

Researchers are using this laboratory prototype to evaluate automated techniques for creating, updating and analyzing digital terrain data. TAWS computer programs use information on such terrain factors as elevation, slope, soil and vegetation to help analysts predict the effects of the terrain on the performance of Army weapons, sensors, vehicles and equipment. With TAWS software, operators can generate terrain analysis products that can help commanders plan military operations.

"We wanted to acquaint troops in the field with these digital terrain analysis capabilities," explained Laslo Greczy, an ETL project engineer who participated in the three-week demonstration.

"We also wanted to get feedback from users to help us refine data base update and revision design requirements for the Digital Topographic Support System," Greczy said. ETL researchers are working with the Troop Support Command to field this system. It will give Army terrain teams access to the type of automated capabilities demonstrated in Germany.

During the demonstration, scientists taught soldiers from the 518th and 526th Engineer Detachments how to use TAWS to analyze the terrain and produce map overlays depicting its effects on specific military operations. Representative products show mobility conditions, predict sensor coverage, identify potential river crossing sites, assess concealment and provide other information which can help commanders make decisions on the battlefield.

After the soldiers mastered TAWS, they put it to work. "One of our goals was to show that automated terrain analysis techniques could be used effectively outside of a laboratory setting," explained MAJ John Quick, an ETL research coordinator who worked with division officials to arrange the demonstration.

Division officials were briefed in advance on TAWS capabilities. They were particularly interested in TAWS intervisibility products—products which map out areas that can be seen, either electronically or optically, from a given location. They identified specific products they could use for the REFORGER exercise and submitted their requirements to the division terrain detachment.

"We were surprised at the number of requests we received," Quick said. In 12 days, scientists and soldiers used TAWS to generate over 600 products for the division and V Corps. "We planned the demonstration as a working-level exercise," Quick said. "We think we were able to provide products that will help the division. We also learned a lot by getting real soldiers in front of our hardware and software."

Scientists report that the terrain analysts were impressed by TAWS' speed and flexibility. They agreed that the system's automated capabilities offer a significant improvement over the manual terrain analysis techniques they now use. One terrain team commander estimated that it would take him three days to turn out a single overlay like the ones generated during the demonstration.

The soldiers also pointed out some problems with TAWS. "We got some valuable feedback on what needs to be improved in software design and what improvements are needed to make the equipment more user friendly," Greczy said. "We also expect to get some long-term feedback from the division on the utility of the products created during the demonstration," he added.

ETL scientists plan to conduct similar demonstrations with other units. Feedback from these exercises will help researchers ensure that the equipment they're developing for the field will provide improved terrain analysis support.

HMMWV Testing

For the past 18 months, various versions of the High Mobility Multipurpose Wheeled Vehicle (HMMWV) have undergone extensive testing at the U.S. Army Combat Systems Test Activity (CSTA). The vehicle is designed to meet the need for mobility in a tactical field environment. The cost-saving HMMWV replaces the M151A2 Jeep, the M561 Gamma Goat, and the M880 non-tactical vehicle.

In accordance with the new high-mobility concept of conducting land warfare, a new wheeled vehicle must be air transportable, assume versatile combat roles, be reliable, maintainable and survivable in a combat situation.

Features of the HMMWV include a diesel engine, power steering, automatic transmission, power brakes and a common chassis upon which several different bodies can be built such as a troop carrier, utility cargo vehicle, ambulance and weapons carrier.

The current CSTA test effort is focused on the S-250 shelter carrier which is designed to carry communication equipment. The carriers are undergoing rigorous endurance testing, according to Bill Sulak, CSTA test director for the project.

"We put the HMMWVs through a series of tests to determine the vehicle's reliability, availability, maintainability and durability," explained Sulak. "Endurance testing determines how well the vehicle performs over various road surfaces over a long period of time," Sulak said.

In addition to endurance testing, comprehensive engineering performance tests are being conducted. The vehicle's capability to clear 18- to 20-inch obstacles, its ability to negotiate steep slopes, and braking performance along with its steering and handling ease are evaluated as part of the test process. Specific tests such as the vehicle's ability to ford water at depths from 30 to 60 inches are also part of the performance test cycle, according to Sulak. The CSTA test team also determines the HMMWVs ability to start and operate from minus 25 degrees Fahrenheit to minus 50 degrees Fahrenheit.

Comprehensive testing of the High Mobility Multipurpose Wheeled Vehicle includes assessing the vehicle's reliability, availability and maintainability as well as measuring specific engineering performance characteristics.

The endurance test cycle for the shelter carrier includes test vehicles being driven a total of 20,000 miles for RAM-D testing at three CSTA test sites. For example, at the Munson test course each HMMWV will travel more than 6,000 miles over gravel and cobblestone roads. The vehicle's capability on secondary roads and cross-country terrain will be tested at the Perryman test area as well as on rough hilly terrain at the Churchville test site. Test plans call for drivers to travel 10 hours a day, six days a week until 20,000 miles of endurance operations are completed.

"If a vehicle passed all tests here, it should hold up well in the field," Sulak said.

Rough Terrain Container Crane

Engineers at the U.S. Army Troop Support Command's Belvoir RDE Center, Fort Belvoir, VA, have added a rough terrain crane capable of handling standard international shipping containers weighing up to 67,200 pounds to the list of commercial materials handling equipment that can be bought "off-the-shelf" by the Army.

A performance specification for the crane was developed under the Army's Nondevelopment Item (NDI) Program and approved as the procurement document. The crane has been type classified and will replace the 50,000-pound rough terrain container handler and the 20-ton rough terrain crane in general support ammunition units and will displace the 140-ton crane for certain applications in some transportation units.

The NDI program is designed to reduce Army R&D time and costs by taking advantage of R&D performed by industry. It involves market surveillance and investigation, followed by development of a technical data package. This procurement package incorporates the performance specifications, and requirements for training manuals, spare parts, accessories, etc. The program has been particularly effective with the highly competitive construction/materials handling equipment industry. Since 1969 the Belvoir RDE Center has provided tech data packages for procurement of 40 rear area use items.

The new crane specifications call for the capability of the crane to lift a 20-foot container weighing 44,800 pounds at a 27-foot radius and a 35/40-foot container weighing 67,200 pounds at a 22-foot radius. This will allow operators to increase productivity while working in limited spaces in ammunition unit storage areas. Because of the crane design characteristics, it can serve the dual functions of handling break bulk cargo and standard international shipping containers.

The crane is intended for issue to general support ammunition units, transporting terminal service units and transportation cargo transfer units. In operation, it will replace the 50,000-pound rough terrain container handler in general support ammunition units and will become part of the Army's container handling equipment.

Awards. . .

ARO Employees Receive Awards

Dr. Robert G. Ghirardelli and Dr. Bernard F. Spielvogel, staff members at the U.S. Army Laboratory Command's Army Research Office (ARO), Research Triangle Park, NC, are recent recipients of awards for outstanding achievements.

Ghirardelli, director of ARO's Chemical and Biological Sciences Division, received the Army Chemical RDE Center Commander's Award for Civilian Service. He was cited for "outstanding initiative in transferring information across the Army-University interface," for "strengthening the U.S. chemical-biological defense research program" and for "his support of the mission of the U.S. Army Chemical Research and Development Center." In addition to his employment at ARO, Ghirardelli is adjunct professor of chemistry at Duke University and is chairman of the Durham City Board of Education.

Spielvogel, chief of ARO's Inorganic Branch, Chemical and Biological Sciences Division, was presented with the Issai Lefkowitz Award for Scientific-Technical Achievement in Army Research. He was cited specifically for his research on the synthesis of boron compounds (including boron analogues of amino acids). This work is considered to have great potential in the treatment of cancer patients and for providing protection against nerve agents. Spielvogel was also recognized for his management of a major element of the Army's basic research contract program in chemistry. He is also adjunct professor of chemistry at Duke University.

CRDEC Honors 3 Scientists

Three civilian scientists at the U.S. Army Chemical RDE Center (CRDEC), Aberdeen Proving Ground, MD, have been awarded Outstanding In-House Laboratory Independent Research Study Awards in recognition of their research contributions during fiscal year 1985.

Drs. Robert S. Anderson, William E. White Jr., and Wayne G. Landis were honored at an awards ceremony at CRDEC Headquarters.

The In-House Laboratory Independent Research Program is designed to improve the quality of Army laboratories, fund new thrusts in laboratory mission areas, and fund seed projects for future programs. This program also reflects CRDEC's ability to attract and retain top scientists and engineers and gives the technical director flexibility for technical entrepreneurship.

Anderson, a research biologist in the Biotechnology Division, Research Directorate, was cited for his research entitled, "Development of Fish Monoclonal Antibodies To Chemical Agents," and for a joint research effort with Dr. Landis.

Anderson has a bachelor's degree in biology from Drexel University, a master's degree in mammalian physiology from Hahnemann Medical University, and a doctorate in immunobiology from the University of Delaware. He has been employed at CRDEC since August 1982.

White, a research biologist in the Biotechnology Division, was recognized for his research project entitled, "Enzymatic Degradation Of Chemical Agents." He has a bachelor's degree in chemistry from Vanderbilt University and a doctorate in organic chemistry from the University of Alabama. He has been employed at CRDEC for two years.

Landis, an environmental scientist in the Toxicology Division, Research Directorate, was cited for his joint work with Anderson for a research study entitled, "Biotransformation Of Toxins By Microorganisms." Landis has a bachelor's degree in biology from Wake Forest University, a master's degree in biology and a doctorate in zoology, both from Indiana University, and has been assigned to CRDEC since January 1982.

Capsules. . .

Composite Rollbar

The U.S. Army Materials Technology Laboratory's composite rollbar for the M102 105mm Towed Howitzer weight reduction effort is currently focusing on replacement of the weapon's steel rollbar. The newly-designed rollbar is a fiber reinforced composite fabricated from filament wound glass epoxy in combination with aluminum. This redesign was successful in reducing the weight of the component from 160 pounds in steel to 40 pounds in composites.

The rollbar prevents damage during transport to the expensive optical components on the Howitzer. It will be field tested at Fort Sill, OK, for one year in a cooperative effort with the U.S. Army Training and Doctrine Command.

Successful SRHIT Flight

The U.S. Army, under the auspices of the Strategic Defense Initiative Organization, has conducted its fourth flight experiment in the Small Radar Homing Intercept Technology (SRHIT) program at White Sands Missile Range, NM. Preliminary results indicate that the experimental flight vehicle, guided by a built-in active radar, successfully homed on and came within a predicted accuracy of a stationary target within the atmosphere. Detailed analysis is being performed on the telemetry data and will be available soon.

The target, an aluminum sphere 44 inches in diameter, was suspended 3,000 feet below a large helium-filled balloon positioned at an altitude of 15,000 feet. The 12-foot long SRHIT flight vehicle was launched in a guided trajectory, reached hypersonic velocity, and homed on the target with its built-in radar system.

The overall objective of the SRHIT technology validation program is to determine the in-flight characteristics of a highly maneuverable, radar homing, non-nuclear flight vehicle operating within the atmosphere. Proof-of-principle flights against moving targets are included in subsequent missions.

Career Programs. . .

BRL Announces 1986 Postdoctoral Program

The Ballistic Research Laboratory has announced its 1986 program for resident research associateships in conjunction with the National Research Council (NRC).

The program has two objectives. The first is to provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are compatible with the research interests of the sponsoring laboratories. The other objective is to contribute to the overall research efforts of federal laboratories.

A national competition is conducted by the National Research Council to recommend and to make awards to outstanding scientists and engineers at recent postdoctoral and experienced senior levels for tenure as guest researchers at participating laboratories.

This program has been conducted with federal agencies since 1954. The BRL has participated since 1965.

According to Dr. Lawrence J. Puckett, BRL assistant director, "The postdoctoral associateship program provides fresh intellectual resources to the BRL. The caliber of the postdoctoral associates is adjudged, by the National Research Council, to be in the top 10 percent of those receiving doctorates in the science and engineering disciplines. Along with such intellectual prowess, the associates bring to the BRL unique university and industrial sector views of the state of particular technologies of importance to the Army."

The Ballistic Research Laboratory goes to great lengths to accommodate individual research needs of associates and to assure that each associateship assignment provides a mutually satisfying experience.

"As testimony to the success of our efforts, and to the rewards of postdoctoral associateships at the BRL, we are currently averaging eight to 10 associateships a year," Puckett said. "An even greater sign of success, however, is found in the realization that many of the associates, upon completion of their NRC associateship, have elected to join our present scientific staff," he added.

BRL is the Army's lead laboratory in ballistics and vulnerability/lethality analysis.

The laboratory's products contribute to advanced technology systems suitable for engineering development and production. The objectives of these activities are to provide the Army with weapons it needs to remain a first-class fighting force and to preclude technological surprise.

In order to fulfill these needs, the BRL draws on available science and technology where possible and performs research where needed. In the latter case, laboratory programs supplement other defense-supported research by addressing many of the scientific areas inadequately treated by industrial and university research programs that may result from the nonavailability of suitable facilities and resources.

According to Dr. Puckett, the program at the BRL includes opportunities for research in the fields of applied mathematics, probability theory and stochastic processes, combustion research, fluid mechanics, structural and material sciences, physics and physical chemistry.

These areas of research are included within the five divisions of the BRL: the Interior Ballistics Division, the Terminal Ballistics Division, the Launch and Flight Division, the Vulnerability/Lethality Division, and the Systems Engineering and Concepts Analysis Division.

Basic criteria for eligibility for the program include U.S. citizenship (foreign nationals may be accepted for certain research opportunities) and the possession of the Ph.D., Sc.D., or other earned research doctoral degrees recognized in U.S. academic circles as equivalent to the Ph.D. In the alternative, the applicant must present acceptable evidence of having completed all the formal academic requirements for one of these degrees before tenure may be initiated.

Detailed information concerning research opportunities at the BRL can be obtained from: Dr. Lawrence J. Puckett, U.S. Army Ballistic Research Laboratory, ATTN: SLCBR-DA, Building 328, Aberdeen Proving Ground, MD 21005-5066, Telephone: (301) 278-6245.

Detailed information on application procedures, all necessary forms, and a list of the supporting documents required are available from: Associateship Programs (JH 608), National Research Council, 2101 Constitution Avenue, N.W., Washington DC 20418.

Scientists and Engineers Get Hands-on Experience

A program to provide scientists and engineers with the latest in producibility training and development has been established by the Center for Defense Science Studies at the U.S. Army Armament Research, and Development and Engineering Center (ARDEC), Dover, NJ.

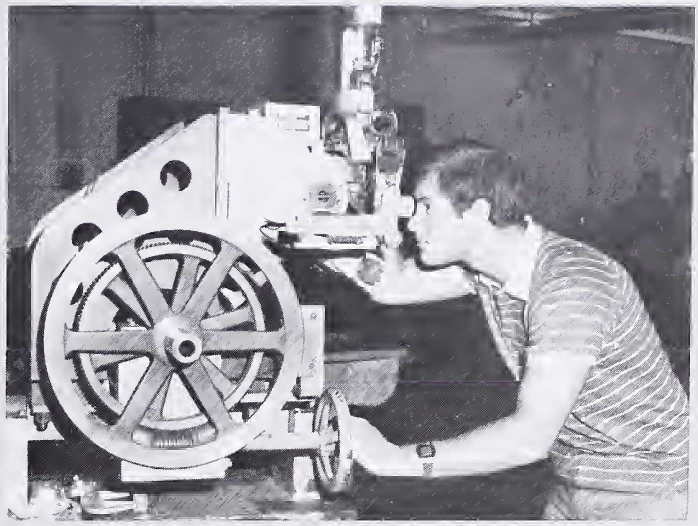
Part of the producibility program is the Armament Community Resident Engineering (ACRE) program. Assignments of two to 12 months provide scientists and engineers with on-site work experience at ammunition plants, depots or field service activities.

The skills and knowledge derived from learning by doing will have long-term benefits toward the designing of weapons and munitions which are producible and easily maintained, according to the ARDEC Technical Director Al Moss.

Many engineers are hired straight out of college and haven't had experience in a manufacturing atmosphere. Experience in production plant operations, fabrication, major item reclamation/rebuild, product improvement retrofit, logistics, depot supply and maintenance, can be obtained through the ACRE program, according to Sandi Cherenack, ACRE program representative.

A recent ACRE participant at Letterkenny Army Depot, Michael Zecca, a mechanical engineer in the Product Assurance Directorate, U.S. Army Armament Munitions and Chemical Command, Dover site, said that prior to the ACRE program all his work was with paper. He had no hands-on experience with the instruments or the equipment they were installed into.

"In the ACRE program I worked with the actual instruments," he said. "I took them apart, cleaned and repaired them and installed them into the vehicles. Now, when I work with the technical data packages, I actually know what the product looks like and where it will be installed."



Michael Zecca peers into an M117 telescope to check the M145 telescope mount. Zecca completed a 90-day assignment at Letterkenny Army Depot, PA, as part of the ACRE program.

Another part of the producibility program is formal courses in manufacturing technology which are conducted on-site in cooperation with local universities. Descriptions and schedules of classes now available at other government agencies such as the U.S. Air Force Institute of Technology located in Dayton, OH, and the U.S. Army Management Engineering Training Activity located in Rock Island, IL, are also available.

Loading, assembling, packing and manufacturing will be covered in courses to be held at ARDEC, depots or ammunition plants. These three-week courses will familiarize engineers and scientists with the manufacturing environment.

WRAIR Researchers Win Fellowships

Two researchers assigned to the Walter Reed Army Institute of Research (WRAIR) have been selected for Army Science and Engineering Fellowships. They are two of seven finalists in an Army-wide competition for the fellowships.

Dr. Jeenan Tseng, chief of the Department of Experimental Pathology, Division of Pathology, and Dr. Sara Rothman, a research chemist in the Department of Biological Chemistry, Division of Biochemistry, are WRAIR's finalists.

Tseng will study lymphocyte migration in the body. Lymphocytes are antibody-producing cells which help the body fight disease and infection. Tseng will explore the possibility of controlling and directing lymphocyte migration to infection sites and tumors. He will conduct his research at Johns Hopkins University in Baltimore. Tseng holds a Ph.D. in immunology from the University of Illinois and has worked at WRAIR since 1979.

Rothman plans to use recombinant DNA technology to study pathogenic clostridia, bacteria that cause a variety of diseases and infections. She will conduct her research at the Oregon Health Sciences University in Portland, OR. She holds a Ph.D. in microbiology and biochemistry from Boston University School of Medicine. She has worked at WRAIR since 1978.

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